MOTOR MANUALS

VOLUME TWO

CARBURETTORS AND FUEL SYSTEMS

ARTHUR W. JUDGE

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MOTOR MANUALS

A SERIES FOR ALL MOTOR OWNERS AND USERS

VOLUME II

CARBURETTORS AND FUEL SYSTEMS

THE THEORY, PRACTICE, TESTING, TUNING AND MAINTENANCE OF CARBURETTORS, COAL AND PRODUCER GAS SYSTEMS AND PETROL INJECTION METHODS

BY

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PREFACE TO FOURTH EDITION.

The present edition has been brought up to date and a good deal of new material and illustrations added. In keeping with the previous editions the practical requirements of the motor engineer, mechanic and student have been given special consideration, the purely academical aspects being kept to the minimum.

In view of the growing importance of producer gas and coal-gas driven vehicles a new chapter has been included on these subjects. Another new chapter deals with petrol-injection spark-ignition engines—a type which is now in active development for aircraft, automobile and stationary engine purposes.

Certain descriptions of earlier carburettor types have been retained, intentionally, in the present edition, primarily on account of their historical interest and of the original principles employed. On the other hand the accounts of some of the earlier models and equipment, appearing in the last edition, have been omitted.

With these deletions and the inclusion of a considerable amount of new matter it is hoped that the general value and scope of the present edition will serve to maintain the interest which has been shown in the earlier editions of this book.

A. W. JUDGE.

Farnham, Surrey,
1941.

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CHAPTER I

CARBURATION IN THEORY

Introductory.—The modern automobile has rightly merited its present reputation for efficiency and reliability, as a result of a considerable amount of design development and attention to detail, with a result that the owner of a new car seldom experiences any trouble with his engine during the first 10,000 miles or so of running. On the other hand there is a number of older automobiles in present use which have had various amounts of hard wear and usage. It is partly in the interests of the owners of these latter vehicles that the present volume is written.

An elementary knowledge of the combustion and carburation principles and facts will enable the user of automobile engines not only to tune up his engine to the best advantage as regards power output, slow-running and fuel economy, but will prove of much help in connection with the diagnosing of carburation troubles when they occur—and their occurrence is one of the most frequent of those troubles which are occasionally met with in automobile engines.

The carburettor is at once the most important, and the least understood component of the engine, from the user's viewpoint. Just as it is frequently stated that "the engine is the heart of the car" so we can truly say "the carburettor is the soul of the engine."

It is proposed to devote part of the present chapter to a brief consideration of some of the facts and modern conjectures regarding the important subject of the explosion or combustion process, in order that the basic ideas of carburation may be properly grasped.

It will be assumed that the reader is acquainted with the working principles of the petrol-type engine, such as the two- and four-stroke cycles, and the general construction and working of ordinary and special types of automobile engines as described in Volume I of these manuals on "Automobile Engines".

The Combustion Process.—The petrol-type engine may be regarded as an engine or prime mover, which depends for its working upon the extraction of heat from the liquid fuel used. In order to extract this heat from the fuel, means are provided to break the liquid fuel up into a fine spray, or mist, that is to atomize the liquid, and to mix this atomized fuel with the proper quantity of oxygen in order that the resulting mixture may explode when a spark is applied. The function of the carburettor is to supply, under all conditions of engine working, the right proportions of atomized fuel and oxygen for combustion.

Let us now inquire a little more fully into the subject of the combustion process, and endeavour to understand what is meant by this expression; it will be necessary to refer to the chemical side for this purpose.

Atoms and Molecules.—All substances in the universe are made up of one or more simple particles or *Atoms*, known as Elements. At present there are about 70 of these elements known to chemists; lead, iron, silver, and carbon are examples of solid elements, whilst oxygen, hydrogen and nitrogen (designated by the symbols O, H and N respectively) are among the gaseous elements. Most existing materials are made up of two or more of the elements combined together; these combinations are known as *Compounds*, and the smallest particles of such compounds are known as *Molecules;* the molecule contains the atoms of the elements concerned. Thus ordinary pure water is a compound of oxygen and hydrogen; it has a chemical formula H_2O, which is merely a convenient method of stating that a molecule of water contains two atoms of hydrogen and one atom of oxygen.

Chemistry of Engine Fuels.—Most of the liquid fuels used in the carburettors of automobile engines are

compounds of hydrogen and carbon. Thus a nearly pure petrol, known as *Hexane*, is a compound denoted by the chemical formula C_6H_{14}, which indicates that the molecule of hexane contains six atoms of carbon, and fourteen of hydrogen. It is called a hydrocarbon.

Most of the ordinary elements such as carbon and hydrogen, and most of the metals, will unite chemically with oxygen to form compounds, and in thus uniting evolve much heat. Thus hydrogen and oxygen will combine to form water according to the relation

$$2H_2 + O_2 = 2H_2O.$$

This indicates that two volumes of hydrogen require one volume of oxygen to combine, and will form two volumes of water in the form of steam.

This chemical combination process is termed Combustion, and is always accompanied by the evolution of heat. For example, when petrol (hexane) is atomized, or vaporized, and mixed with about $3\frac{1}{2}$ times its weight of oxygen, it will combine, or burn, with much heat, and the products of combustion will consist of steam (H_2O) from the hydrogen part and carbon dioxide, or carbonic acid gas as it is sometimes termed (CO_2), from the carbon part of the fuel.*

Why Oxygen alone should not be used in Petrol Engines.—Before concluding these elementary considerations let us add that it is not convenient, nor is it usually safe, in automobile engines, to use pure oxygen. Atmospheric air, which is a mixture (not a compound) consisting of 76·8 per cent. nitrogen and 23·2 per cent. of oxygen, or roughly 3 parts N to 1 part O, by weight, is much more convenient to use, but it necessitates taking into the engine about three times as much nitrogen as oxygen, and since it is impossible to burn nitrogen, this gaseous element passes right through the engine unchanged. It is a most useful item, however, since it dilutes the oxygen

* The combustion process is expressed by the relation $C_6H_{14} + 9\frac{1}{2}O_2 = 6CO_2 + 7H_2O$ showing that 1 volume of hexane requires for combustion $9\frac{1}{2}$ volumes of oxygen, the products of combustion consisting of 6 volumes of carbon dioxide and 7 volumes of water (steam)

fuel mixture and prevents the excessive pressures and temperatures which otherwise would occur—in fact, without nitrogen it would be almost impossible, and certainly impracticable for the petrol-type engines to work safely. Whether, in the search for light and compact engines of the future, oxygen in the liquid form will be used for specially designed engines with various fuels remains to be seen, but there are undoubted possibilities in this direction.

Difference between Inflammation and Detonation.—It is important to distinguish between the different types of explosion which can occur in internal combustion engines, namely those of *Inflammation* and of *Detonation*. The former process is, relatively speaking, a slow one, and consists in the spreading more or less gradually of the flame from particle to particle; it can best be illustrated by the igniting of a mixture of ordinary coal gas and air in a long tube (closed at one end) at the closed end, when the passage of the flame can be watched as it moves towards the open end. Again, if a piece of gun-cotton be placed on a saucer it will burn without explosion, but if it be fired rapidly as with a percussion cap a violent explosion, or detonation, will occur. Similarly it is possible to explode the coal gas and air mixture in a tube and to cause it to detonate. In the inflammation process the flame travels along at the rate of a few feet per second; in detonation it travels at a few thousand feet per second. In petrol-type engines detonation may be due to (*a*) The use of pure oxygen instead of air. (*b*) The use of acetylene gas and air as the explosive mixture. (*c*) Too high a compression pressure for the fuel used. (*d*) Too much turbulence in the mixture. (*e*) Incorrect design of combustion chamber.

Very high pressures occur during detonation and engines which are designed for ordinary pressures may be severely stressed in consequence. One has seen several examples of fractured cylinders and pistons due to the use of acetylene gas in ordinary petrol engines.

The ordinary combustion process in automobile engines is neither true detonation nor inflammation,

the diluting effect of the nitrogen and of the exhaust gases which remain in the cylinder at the end of the exhaust stroke preventing the former process. It is possible, however, as we have mentioned before, to promote detonation by using a low grade or octane fuel such as paraffin, and a relatively high compression pressure, say of from 100 to 120 lbs. per sq. in. When we come to consider the subject of fuels, it will be seen that some fuels will withstand much higher compression pressures, without detonation, than others.

Pre-ignition and Carbon Deposit.—Pre-ignition is not the same as detonation. Detonation is distinguishable from pre-ignition in that it always occurs after the ignition spark, whereas pre-ignition precedes the spark.

Usually, pre-ignition is caused by local overheating of the combustion chamber, such as the sparking plug points, projecting particles of carbon or metal. Running for long periods with the spark too far retarded will also cause pre-ignition. Detonation if allowed to persist in an engine causes serious local overheating in the cylinder, with the result that any projecting points such as local prominences on the inside of combustion chamber casting or the sparking-plug points become heated to redness, and thereby ignite the fresh charge at an early stage of the compression stroke, the explosive force thus caused acting against the direction of motion. When an engine has run for a long period, the lubricating oil escaping past the piston becomes carbonized, and a carbonaceous deposit is formed on the non-sliding surfaces of the combustion chamber. In addition the mixture of air and petrol, if too rich deposit carbon, and a certain amount of siliceous matter from the road dust, which is drawn in with the air, both assist in forming the hard deposit. This layer acts as a non-conductor of heat, and prevents the cylinder head and piston from losing sufficient heat, to keep cool enough. The compression of the engine is also raised, due to the space taken up by the deposit, so that from both causes detonation occurs, followed by pre-ignition. In such cases when the engine is run under load on

full throttle it will exhibit a sharp metallic-like knock, known as "pinking," and will eventually cease working altogether.

How the Explosive Effect is Derived.—In order to utilize the heat of combination of the oxygen of the air supply with the carbon and hydrogen of the fuel, it is necessary to utilize a closed cylinder, and the usual piston mechanism as shown schematically in Fig. 1. At the time of complete combustion, or immediately afterwards, the maximum pressure occurs,

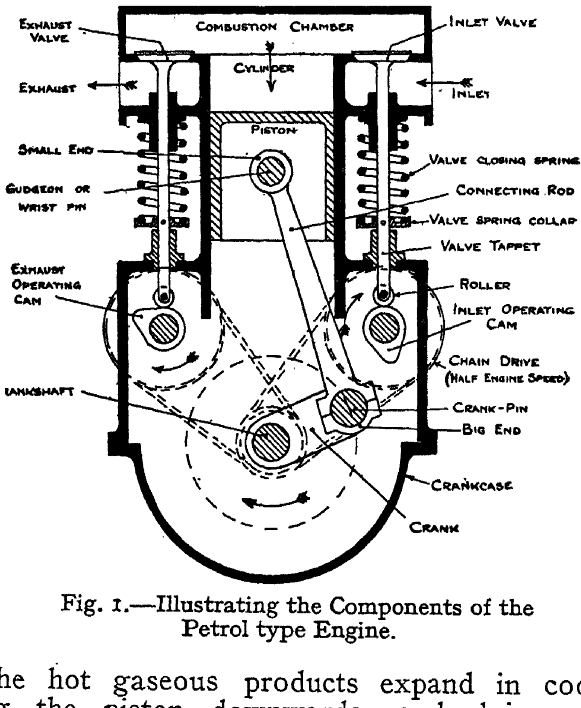


Fig. 1.—Illustrating the Components of the Petrol type Engine.

and the hot gaseous products expand in cooling, forcing the piston downwards, and doing useful mechanical work thereby. The reciprocating action of the piston is converted to one of rotation by the piston connecting-rod crank mechanism shown. In the case of the ordinary automobile engine a mixture consisting of about 1 part by weight petrol, and 15 parts of air is compressed to about one-sixth,* thereby giving a

* The compression ratio in this case is expressed as 6 to 1.

compression pressure of about 120 lb. per sq. in. at the end of the compression stroke. After the compressed gas is ignited the pressure suddenly rises to about 350 to 400 lb. per sq. in., and during the firing stroke of the piston falls progressively to above 30 to 50 lb. per sq. in. when the exhaust valve opens, thereafter dropping to atmospheric value. The average pressure exerted, taken over the complete firing stroke, is about 95 to 100 lb. per sq. in. It should be remembered that in the case of a four-stroke engine there is one useful, or firing, stroke and three idle strokes per cylinder. The idle strokes are necessary for drawing in the fresh charge, compressing it before firing, and for expelling the burnt gases.

Heating Value of the Fuel.—The more common fuels that can be used in automobile engines, include the petrol series, benzole and paraffin, or mixtures of these. Each fuel has its own peculiar characteristics; these will be referred to subsequently.

When any particular fuel is atomized or vaporized and mixed with the right quantity of oxygen, and exploded, it yields a definite amount of heat. Thus 1 lb. of petrol of specific gravity 0·720 will give out sufficient heat on exploding with oxygen to raise the temperature of 105 lb. ($10\frac{1}{2}$ gallons) of water from freezing point (32° F.) to boiling point (212° F.). The Heating or Calorific value of a fuel is defined as the quantity of heat evolved by the complete combustion of 1 lb. of the fuel, and it is usual to express *this quantity of heat in British Thermal Units** (or B.T.U.'s). Thus the Calorific Value of the above ade of petrol is given as 19,000 B.T.U.'s $= 105$ $°\,F - 32°\,F) = 105 \times 180$.

Most of the ordinary fuels used have calorific values ranging from 18,000 to 20,000 B.T.U.'s, except alcohol which has a value of 12,600 B.T.U.'s. Table No. 1 gives the principal properties of the fuels in common use, and also of a few others.

* A British Thermal Unit is the quantity of heat required to raise the temperature of 1 lb. of water through 1° Fahrenheit, at 32° Fahrenheit.

TABLE No. I.

Showing Principal Properties of Different Fuels for Petrol-type Engines (Ricardo).

Name of Fuel.	Chemical Formula.	Weight per Gallon (in lbs.)	Calorific Value in B.T.U.'s (per lb.)	Proportions of Air to Fuel, by Weight, for Complete Combustion.	*Greatest Compression Pressure which has been used satisfactorily.	Lowest Fuel Consumption recorded in lbs. per I.H.P hour.	Greatest M.E.P. Value obtained.
Petrol (Gasolene)	Mixture of Light Petrols	6·8	19,200	15·3	Lbs. per sq. in. 95	·440	133
,, Medium .	Do.	7·2	18,700	15·1	105	·422	138
,, Heavy .	Do.	7·6	18,250	14·6	121	·407	143
Paraffin (Kerosene)	—	8·13	18,900	15·0	86	·581	—
Benzene (Pure) .	C_6H_6	8·84	18,500	13·2	140	·390	156
Pure Alcohol .	C_2H_6O	7·95	11,600	9-10	204	·532	165
80% Alcohol .	—	8·36	8,750	8-9	—	—	—
Methylated Spirits	Mixture	8·21	11,000	8·0	164	·625	165
Ether (50% in Petrol)	Do.	7·3	—	13·0	77	—	132
Carbon Disulphide (50%) .	CS_2 50%	9·94	—	10·8	115	—	136
Acetylene ...	C_2H_2 (Gaseous)	—	21,600	—	—	—	—

* Generally referred to as the Highest Useful Compression Ratio, or, H.U.C.R.

Properties of Petrol-Air Mixtures.—In order to appreciate the operation of the carburettor it is necessary to know the properties of the working mixture. Confining ourselves for the present to petrol, it has been shown experimentally that a petrol engine will work with a range of mixtures extending from the weakest (in petrol) consisting of about 22 parts, by weight, of air to 1 part petrol, to the richest (in petrol) of about 8 parts of air to 1 of petrol. The mixture which gives complete combustion according to chemical combination requirements is usually one composed of about 15 parts of air to 1 part petrol, for petrol of specific gravity (S.G.), ·72.

Weak mixtures in general give *less power* (i.e., mean effective pressure on the piston) than the correct, or "*Optimum*" mixture, but nevertheless have been shown, conclusively, to give *better fuel economy* for a given power output than richer mixtures. Weak mixtures result in a *slower rate of explosion*, and in the case of very weak mixtures the rate of explosion may be so slow that the explosion has not finished by the time the next inlet stroke occurs. The flame in this case may travel past the open inlet valve, and into the carburettor, causing a mild explosion in the latter. This phenomenon is known as *Popping in the Carburettor*. When using weaker mixtures, owing to the slower rate of pressure rise after ignition, the ignition lever should be advanced so as to cause the spark to occur earlier in the compression stroke; as much as 40° to 50° angle of advance, before the top dead centre of the engine, on the compression stroke may be given.

Weak mixtures contain, of course, an excess of air over that required for complete combustion, so that after explosion the exhaust gases will also contain an *excess of oxygen* and *nitrogen*.

Rich mixtures in general give *more power* than the optimum and weak ones up to a certain degree of richness, namely, about 11 to 12, after which the power falls off, progressively. The rich mixtures of from 12 to 15 give the *maximum power output* (or

mean pressure) but are less economical in petrol consumed per horse power hour.

Rich mixtures also possess a *higher explosive rate*, and are therefore preferred for very high speed and compression engines. As the mixture is progressively enriched from about 11 to 8, the power falls off, the explosive rate diminishes, and the mixture having insufficient oxygen to consume the petrol present, begins to deposit carbon in the form of a fine powder inside the cylinder.

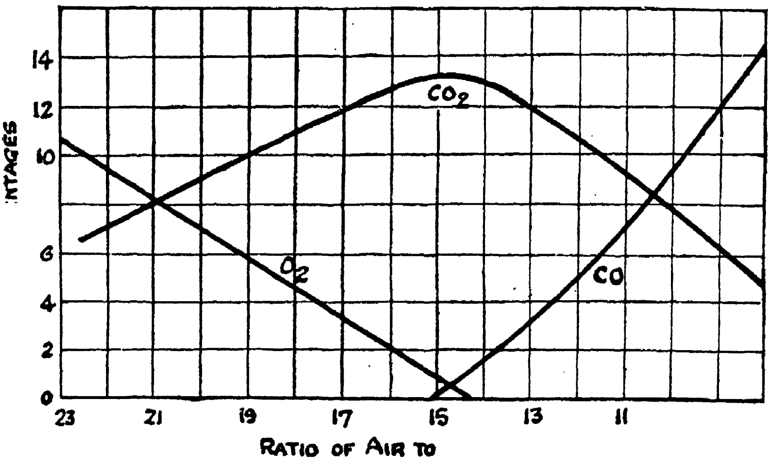


Fig. 2.—Exhaust Gas Constitution Diagram.

Very rich as well as *very weak mixtures*, owing to their slower explosion rates, are very liable to *cause overheating* of the engine, for the cylinder walls and residual exhaust gases become hotter. Pre-ignition may occur in such cases.

The Exhaust Gases.—Rich mixtures contain insufficient oxygen in the air supply, and so do not burn properly, but only partially; the exhaust gases therefore contain imperfectly burnt carbon in the form of *Carbon monoxide* (CO) as well as carbon dioxide (CO_2) but no oxygen. It is thus possible to trace back from a chemical analysis of the exhaust gases*

* A full account of the methods and apparatus is given in the author's "The Testing of High Speed Internal Combustion Engines" (Chapman and Hall Ltd.).

the proportions of the mixture given by the carburettor.

The curves given in Fig. 2 show the exact composition of the exhaust gases for a motor petrol of $=0 \cdot 72$ specific gravity when used in a petrol engine. The percentage of nitrogen is not shown, but can readily be deduced by adding the other constituents and subtracting the result from 100. Thus for a mixture ratio of 18, there is $4 \cdot 6$ per cent. of oxygen and 11 per cent. of carbon dioxide, the two totalling 15·6 per cent. The percentage of nitrogen is thus $100 - 15{\cdot}6 = 84{\cdot}4$.

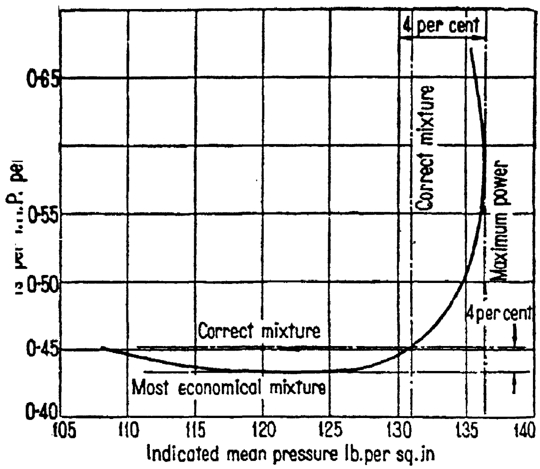


Fig. 3.—Illustrating how the Power depends upon the Mixture Strength.

It will be observed from the curves that for rich mixtures there is no oxygen present, and for weak ones, no carbon monoxide. These facts suggest a useful method of testing an engine for carburation values.

How the Power depends upon the Mixture Strength.—It has been stated that, in general, richer mixtures than the optimum give rather more power, and the power falls off for still richer and also for weaker mixtures. These results are illustrated specifically in Fig. 3, which shows how the m.e.p. developed varies with the mixture strength, and also gives the fuel consumptions. It will be seen the most economical

mixture, namely the weakest one shown, giving a petrol consumption of about 0·43 pints per indicated horse power per hour, gives an m.e.p. of about 123 lb. per sq. in. The correct mixture gives a petrol consumption figure of 0·45, and m.e.p. of 131·5. A rich mixture with a petrol consumption of 0·58, gives the greatest m.e.p. value of 136·5 lb. per sq. in. In this respect it is interesting to note that this richer mixture gives about 4 per cent. higher m.e.p., and most economical mixture about 6½ per cent. lower

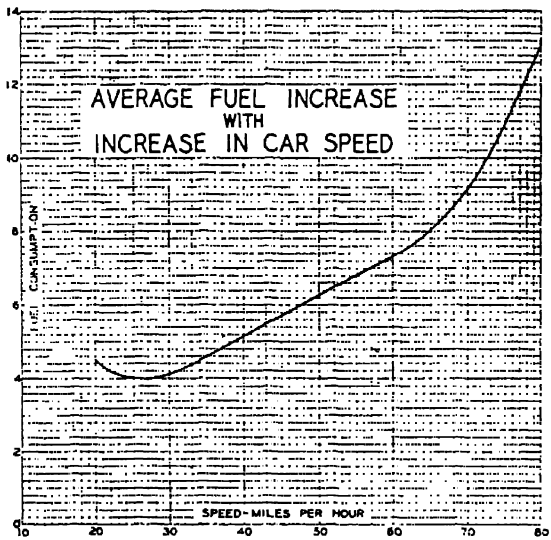


Fig. 4.—Showing effect of Car Speed on Petrol Consumption.

m.e.p. than the correct mixture (0·45). The points of interest to the motorist from these results are that richer mixtures give more power, and weaker mixtures lower fuel consumptions per horse power.

Effect of Speed on Fuel Consumption.—When making comparisons of fuel consumptions of petrol engines it is necessary to take into account their throttle openings, or relative power outputs. Thus, it is a well-known fact that the fuel consumption per horse-power increases with the proportion of power delivered, up to the maximum output.

Similarly, the mileage per gallon of a motor-car

engine will decrease with increase in the road speed of the car up to the maximum road speed attained.

These facts are clearly illustrated in the graph reproduced in Fig. 4. The figures or ordinates at the left hand side represent units of fuel consumed, whilst the abscissæ denote road speed in miles per hour. Thus, if the fuel consumption is 20 miles per gallon at 25 m.p.h., the graph indicates that it will only be 10 miles per gallon at 65 m.p.h. and approximately 6½ miles per gallon at 77 m.p.h.

General Results Summarized.—Most of the information given in the preceding pages may be summarized conveniently in tabular form, as follows:

TABLE No. 2

Showing Principal Properties of Petrol Engine Mixtures.

Proportion of Air to Petrol (by weight).	Designation of Mixture.	Power Output.	Fuel Consumption per H.P. Hour.	Exhaust Gas Composition (Approximate).	Remarks.
20–22	Very weak	Minimum About 40% less than optimum	Low	84·0% N 8·0% CO_2 8·0% O	Low power. Gives rise to backfire or popping in carburettor. Slow burning and erratic running.
16–18	Weaker	About 10% less than optimum	A minimum	84·5% N 12·0% CO_2 3·5% O	The most economical mixture to run on, but not the best for maximum power.
15–15½	Correct or optimum	About 4% less than following richer mixture	About 4% more than minimum	86·8% N 13·2% CO_2 Practically no O	The best compromise. Maximum CO_2 in exhaust.
11½–13	Richer	Gives maximum power	About 25 to 30% more than minimum	84·5% N 10·5% CO_2 5·0% CO	Best for maximum power, but greater fuel consumption. No oxygen in exhaust. Most rapid flame rate.
8–10	Very rich	Gives less power than optimum	Very high	82·0% N 6% CO_2 13% CO with deposit of carbon	Poor results. Low power. High fuel consumption. Much deposited carbon. Low flame rate.

CHAPTER II

FUELS

Available Fuels.—Fortunately, for internal combustion engines, there is a very wide range of fuels upon which they can operate, ranging from the heavier oils used in Diesel engines, through the lighter spirits such as benzole, petrols and alcohol, to the gaseous fuels of which coal-gas and hydrogen are examples. Although it is possible to use the heavier fuels in the ordinary automobile engine, it becomes necessary to employ special vaporizing, or vapour-mixing means, and different air-fuel proportions, but the best results are not obtained except upon petrol, for which the engine was designed. For example, if one were to use paraffin in a modern petrol engine, it would be found that the usual compression pressure would be too high, and the mixture would tend to detonate; less power would certainly be obtained. On the other hand, pure alcohol, or its mixtures with benzole or naphtha, requires nearly double the compression pressure of the petrol engine in order to give its best power and fuel economy. Coal-gas also does not give so much power as petrol if used in petrol engines, but on the other hand requires a much simpler mixture proportioning device. Benzole can stand an appreciably higher compression, without detonation, than petrol, and will give its best results under these circumstances, although even in the ordinary petrol engine it gives from 10 to 15 per cent. more power and from 10 to 15 per cent. lower fuel consumption.

The Use of Heavy Fuels.—It is possible, more particularly in the case of heavy vehicles, that the future may show a tendency in design towards the use of high speed oil engines such as Diesels or semi-Diesels,

which use rather heavier oils. These oils are not used with a carburettor, but are injected, under high pressure, direct into the cylinder in the form of a highly pulverized spray. The piston compresses the air (and residual exhaust gases) only, and the fuel is injected at the top of the compression stroke. In the case of the Diesel engine the compression pressure, viz., about 450 to 550 lb. per sq. in. and the corresponding heat due to this compression is so high that the fuel ignites as it is injected. In the case of semi-Diesel engines, rather lower compression pressures are used, the fuel being sprayed into the combustion chamber which after having once started up becomes hot enough to ignite the injected fuel and thus dispense with the usual external ignition means.

Properties of Fuels.—Confining our attention to the lighter fuels applicable to automobile engines, it can be stated that in general the best fuels are those which contain the highest proportions of hydrogen, for the following reason, namely, that hydrogen has a heating value of 62,000 B.T.U.'s per lb., whilst carbon has only 14,540 B.T.U.'s. Since all of the fuels used in combustion engines consist of carbon and hydrogen (sometimes with the addition of oxygen), the greater the hydrogen content the better the heating value. Too much oxygen in a fuel also lowers its heating value as it reduces the available amounts of hydrogen and carbon. Thus, pure alcohol (C_2H_6O) contains 52 per cent. carbon, 13 per cent. hydrogen and 34·8 per cent. oxygen; it has a heating value of 12,600 B.T.U.'s per lb. On the other hand *hexane* (C_6H_{14}), which is practically pure petrol, contains no oxygen, 83·7 per cent. carbon and 16·3 per cent. hydrogen, and has a heating value of 19,200 B.T.U's per lb. Toluol, one of the constituents of benzole, contains only 8·7 per cent. of hydrogen, the rest being carbon, and has a heating value of 18,300 B.T.U's per lb.

Apart from the heating value, other desirable properties of an automobile engine fuel are as follows: (*a*) A high limiting compression pressure; in general the higher this value, without detonation

occurring, the more power is obtained. (*b*) Good vaporizing qualities, preferably without having to employ external heating means; in this respect paraffin and alcohol are at a disadvantage. (*c*) High flash point,* for safety reasons. (*d*) Good explosion range of mixtures; this renders an engine more flexible and less sensitive to carburation changes. (*e*) Cheapness.

The particulars of the different possible fuels given in Table I, were obtained by H. Ricardo, who employed these fuels in a special type of internal combustion engine, the compression ratio of which could be altered over fairly wide limits, viz., from about 3·5 to 7·5. In the case of the alcohol fuels mentioned at the foot of Table I, the values for the compression and mean effective pressures given represent those obtained with a compression ratio of 7·5, which was the highest available for the engine used; still higher ratios could no doubt have been used before detonation occurred.

Freezing of Fuels.—The fuel should not freeze under the lowest atmospheric temperature conditions; in this respect pure *benzene* (not benzole), which is a light spirit usuable in petrol engines, freezes at 5·4° C. (40·7° F.) If, however, another liquid such as toluene, xylol, or petrol be added, even in small quantities, of the order of 10 to 15 per cent., the freezing point is lowered by at least 10° C. (18° F.). In this connection it should be mentioned that the British Standard Specification for benzole, for motor-car use, stipulates a freezing point not higher than −14° C. (7·6° F.); a benzole mixture consisting of 70 per cent. benzene and 30 per cent. toluene satisfies this requirement. Evidently such fuels as pure benzene and paraxylene (freezing at 16° C.) cannot be used under winter conditions or in cold climates.

Devices for preventing the formation of ice around the jets and in the mixing chambers of aircraft and motor vehicle carburettors are mentioned in Chapter VII.

* The flash point of a fuel is the lowest temperature at which it gives off a vapour which is inflammable.

Particulars of Available Motor Fuels.—Table No. 1.—The reader is recommended to supplement the following notes upon different fuels with a reference to Table No. 1, which gives a good deal of information concerning the suitability of different fuels for automobile engine use. Not only does it give particulars of the fuel densities, or weights, but also shows the proportions of air required for proper explosion, the highest compressions which can be used without risk of detonation and pre-ignition, the possible fuel consumptions and the mean pressures obtainable in the cylinder. It should be pointed out that most of the results given were obtained by H. Ricardo from careful measurements made on a special design of variable compression engine.

Air Proportions and Explosive Range.—It is necessary in considering fuels, their suitability for automobile engines, and the carburettors designed for their particular use, to know the air proportions required not only for complete combustion, but also over the range of fuel-air mixtures on which the engine will work. The air proportions, by weight, for various fuels are given in Table No. 1, whilst the proportions by volume are given in the table below for the more important fuels, both for the optimum mixture and for the useful range of mixtures.

TABLE NO. 3

Properties of Mixtures for Petrol-Type Engines

Fuel.	Proportion of Air for Complete Combustion.		Percentage of Fuel Vapour in Mixture.		
	By Weight.*	By Volume.†	Correct Mixture.	Weakest Mixture which will fire.	Richest Mixture which will fire.
Petrol . .	15	60	1·7	1·0	3·0
Benzole . .	13	32	3·0	2·7	6·3
Alcohol . .	9	14	7·0	4·0	13·6
Paraffin . .	15	74	1·4	0·9	2·5

*Parts of air to 1 part by weight of fuel. † Parts of air to 1 part by volume of fuel.

Petrol.—The name "petrol" is given to the lighter products of distillation of crude petroleum—a mineral product of a heavy dark tarry nature. When the latter is heated to about 145° F. to 155° F. the lighter constituents, namely, hexane (C_6H_{14}), heptane (C_7H_{16}) and octane (C_8H_{18}) are driven off as vapours, and are condensed in special vessels to form petrol.

Petrols vary considerably in composition; the commercial varieties range from the lightest petrols of 0·68 density to the heaviest of 0·78; the heavier petrols are usually termed the Nos. 2 and 3 Grades, and the ordinary motor-car petrols the No. 1 Grades. Light petrol is sometimes termed "Aviation" spirit; it has a lower volatizing temperature.

Petrol, which does not contain *aromatic* constituents (known as *Aromatic-Free*) has a density of about 0·71 to 0·72, and is a good all-round fuel. It can be used satisfactorily in engines, with compressions up to about 106 lb. per sq. in. (corresponding to a compression ratio of 4·85), and will give a fuel consumption as low as 0·422 lb. per I.H.P. hour, and a mean pressure of about 138 lb. per sq. in. By adding certain constituents known as *aromatics* to this petrol, higher compressions and higher power outputs are obtained; the density is also greater. A typical petrol of this class has a density of 0·76, and will work satisfactorily with a compression of 122 lb. per sq. in., giving an m.e.p. of about 143 lb. per sq. in. Petrol is a solvent of rubber, and certain varnishes, so should not be allowed to come into contact with these; it is useful for cleaning motor tubes and covers for repair purposes.

Precautions against Fire.—Most petrols give off inflammable vapour at atmospheric temperatures, and so should not be brought into contact with naked lights.* Owing to its volatility petrol can leak from joints in unions and pipes without detection in the ordinary way. It sometimes leaves a stain on the surrounding metal, and can often be detected by its smell. Ethyl petrol is coloured red, and leaves a

* A lamp, with fine copper or brass wire cover, using the Davy safety lamp principle can, however, be employed.

characteristic stain. In this respect, it is advisable to protect the petrol which is apt to leak from the jets or float chamber of the carburettor from reaching the exhaust pipe, or to the contact breaker of the ignition unit. Many cases have occurred of petrol vapour igniting in this manner.

Should a petrol fire occur, it may, if not too large, be beaten out with a damp cloth, rug or coat. A bucket of sand is useful for this purpose, and indeed any means which prevents the oxygen of the air from access to the petrol. The patent fire-extinguishers, such as Pyrene, sold for the purpose are efficient and convenient—these use a liquid such as carbon tetrachloride, an inert vapour or gas such as phosgene which will not support combustion. Water is useless for putting out a petrol fire; it usually spreads the conflagration.

Regulations concerning Petrol Storage.—Certain regulations are now in force concerning the storage of petrol. Under the Petrol Regulations of 1903, relating to the storage of petrol for motor-car use, not more than 60 gallons of petrol may be stored in any one place, and this must be kept in metal cans of 2 gallons capacity and stored in a building which is divided from the house by a substantial fire-proof partition, and which must have a separate entrance. If kept in a separate outhouse or non-residential building, the latter must be not less than 20 feet away from the nearest house. A special licence is required if petrol is stored in a garage, or building nearer than this distance, and for quantities exceeding 60 gallons. Recent regulations apply to the petrol in the fuel tank of the car or motor cycle, an efficient fire extinguisher being specified for the garage. Most large garages now store their petrol in underground steel tanks, of the Bowser or Bywater system types, and pump the petrol direct through a metering device to the fuel tanks of the motor vehicles.

Benzole.—This fuel, which is derived from coal-tar by a distillation process, is of special interest and importance as being a home-produced spirit, whereas the petrols and paraffins used in this country come

from abroad (America, Galicia, Persia and Rumania), When coal-tar—a coal-gas process by-product—is heated to 80° to 100° C., the liquids which distil over consist chiefly of benzene, toluene and xylene; commercial benzole is a mixture of these liquids. Thus the ordinary "90 *per cent. Benzole*" contains from 70 to 75 per cent. benzene, from 22 to 24 per cent. toluene, and from 4 to 6 per cent. xylene, and minor amounts of certain other hydrocarbons such as paraffins and olefines. Lower temperature distillation of coal yields about 5½ to 7 gallons of benzole per ton of coal treated.

Benzole is a colourless limpid liquid having the characteristic odour of rubber solution. It has a specific gravity of about ·88, and so is heavier than petrol. For this reason, when used in place of petrol in engines, the float should be weighted, otherwise the petrol level will be lower in the jet; to some extent this compensates the mixture for the heavier density. Benzole is highly inflammable, giving off vapour capable of igniting even at freezing point. It also dissolves rubber and most of the oil and spirit varnishes, but not cellulose or synthetic resin ones.

Used in place of ordinary commercial petrol in automobile engines, it has been shown to yield from 10 to 15 cent. more power, and to give lower fuel consumptions by 10 to 20 per cent. To obtain the best results the engine compression should be increased.

The principal advantage of benzole is its higher useful compression ratio; this enables it to be used in high compression petrol engines liable to detonate, without experiencing these effects. It is a fairly common experience that certain car engines which "knock" on hills, on petrol, do not do so when using benzole.

Benzole requires rather less air than petrol, namely 13·2 lb. per lb. of fuel. It is advisable, however, to reduce the jet area of petrol-type carburettors, on account of the greater capillary effect and higher density of benzole, rather than increase the quantity of extra air admitted.

No deleterious effects are experienced when benzole

is used in place of petrol, in spite of occasional statements to the contrary, namely, that gumming of the valves occurs, corrosive acids and excessive carbon deposits are formed. The R.A.C., in 1919, conducted a 10,000 mile road test on a Sunbeam car, using commercial benzole as fuel. During the trial the performance of the car was excellent, and no deleterious effect upon the lubrication was observed. An examination of the engine, which was dismantled after the test, revealed no corrosive effects or tarry deposits, whilst the amount of carbon deposit in the cylinder heads and on the pistons was distinctly less than would have been anticipated for petrol. The commercial 50/50 benzole mixture usually consists of equal parts of benzole and petrol, and has intermediate properties.

Motor Cycles and Benzole Fuels.—Many modern motor-cycle engines, in order to obtain greater power outputs from given cylinder capacities, employ higher compression ratios. Several manufacturers, therefore, have in the past recommended the use of benzole mixtures for their engines; otherwise if the latter are used with ordinary grades of petrol they are liable to detonate and lose power under full load conditions; high octane fuels, however, are not open to these objections.

One leading firm recommends the 50/50 benzole-petrol mixture, and actually fits the appropriate jet sizes in the carburettor for this fuel when the motor cycle leaves the works.

When running on benzole alone *a size smaller jet* is usually required. Benzole alone is suitable for engines which "knock" owing to carbon accumulation in the combustion chamber, in cases where it is inconvenient at the time to decarbonise the cylinder. For heavy work, one-third petrol and two-thirds benzole makes an excellent mixture for motor-cycle engines, although pure motor benzole gives a greater mileage per
llon.

Special Fuel for Schneider Engines.—The Rolls Royce engines fitted to the successful 1929 Schneider Trophy aeroplanes were of the high compression type, using as a fuel a mixture consisting of 10 cu. cms. of tetra-ethyl lead per gallon of benzole. This fuel can be used successfully with compression ratios up to 10:1, without detonation occurring. Used at the higher compressions a considerable increase of power is obtained over ordinary petrols.

Paraffin.—This is one of the higher flash point heavier distillates of petroleums and shales; it includes also the illuminating, or lamp, oils. It has a density of 0·79 to 0·85 according to its composition. It has a lower useful compression pressure, so that if paraffin is used in the ordinary way in petrol engines it is apt to cause overheating and detonation. The highest useful compression pressure is about 90 lb. per sq. in. (compression ratio = 4·2).

Paraffin requires about the same quantity of air per given weight as petrol, but owing to its higher density a smaller jet can be used. To obtain the best results as regards vaporization, it is advisable to utilize part of the heat of the exhaust, by jacketing the mixing chamber with an exhaust gas heated sleeve or pipe coil. It is considered better to vaporize the paraffin with part of the air for combustion and to add the remainder after vaporization. Special carburettors are now available for using paraffin in petrol engines. In most cases the engine is started up on petrol, and after warming up thoroughly is switched over to paraffin. It is quite feasible, however, to dispense with elaborate vaporizers, by employing mixtures of paraffin and petrol, or benzole. A satisfactory mixture contains from 25 to 35 per cent. paraffin; it is an advantage to heat the main air supply, however.

Alcohol.—This spirit is of organic origin, and is obtainable from a large number of organic sources, including the fermentation process product from grain, potatoes, sugar products, cellulose products, and flowers of the mahua. Pure alcohol is not used to any extent for motor fuels, but the *methyl alcohol* which is obtained by distilling wood, and *ethyl alcohol*

which is chiefly of vegetable origin, are the principal forms.

Methylated spirits is another commercial form of alcohol containing substances known as denaturants which render it unpleasant for human consumption. A typical composition is Ethyl Alcohol 80 per cent., Wood Spirit 10 per cent., Petroleum Naphtha 0·5 per cent., and the rest water.

Pure alcohol has a density of ·795, and a heating value of 11,500 B.T.U.'s per lb.; the latter is very much lower than the mineral hydrocarbon fuels mentioned. This low heating value is compensated for, however, by the heaviness of its vapour, and the small volume of air required to burn it (namely, about 9 parts to 1 of alcohol, by weight); actually the correct explosive mixture has about the same heating value per cubic foot as the petrols and benzole. In addition alcohol mixtures are able to withstand very much higher compression pressures without detonation, namely, of 200-210 lb. per sq. in., and accordingly give considerably more power than petrol.

Alcohol when mixed with water has a lower heating value, and a higher density in proportion to the amount of water present. Alcohol has a wider range of useful combustion mixtures with air than petrol.

Alcohol engines, such as those used in Germany, where alcohol production has been officially encouraged, have rather larger valves and piping than petrol engines, due probably to relatively larger volume of the combustion products. Also, owing to the greater latent heat of alcohol (i.e., the heat required to convert the liquid to vapour), especially when water is present, it is necessary to jacket the carburettor with exhaust gases or hot water, and to heat the main air supply to about 350° F; alcohol-air mixtures will not explode below about 65° F. for the above reason. It is possible to obtain relatively high values of the thermal efficiency, with alcohol, namely, from 33 to 36 per cent. (brake).

It is usual to employ, not pure alcohol, but a mixture with benzole or petrol. The following mixtures have been used with satisfactory results:

TABLE No. 4

Alcohol Fuels

Alcohol.	Benzole.	Petrol.	Additional.	Remarks.
70	30	—	—	Can employ compression ratios up to 6·5.
38	30	20	Toluol and Ether } 10	This mixture has been used on aircraft.
Methylated Spirits. 50	50	—	—	Used on certain car engine tests, giving more power than petrol.
50	50	—	—	Used on London Gen. Omnibus Co.'s tests.

A large number of tests was carried out by the London General Omnibus Company in order to ascertain the most suitable mixture for their "B" type omnibus engines. It was found that the last one given in the preceding table was the best for the purpose, with a compression pressure of 123 lb. per sq. in. The results indicated also that as the proportion of alcohol was increased so could the compression be raised; thus with 70 parts alcohol and 30 parts benzole a compression of 160 lb. per sq. in. could be used. It was at these high compressions that the most economical consumptions occurred.

One interesting result of the tests was shown by the corrodibility of the iron and copper fuel tanks when alcohol or alcohol-benzole mixtures were used. No appreciable corrosive effects were observed with brass, zinc, tin or aluminium, whilst lead was quite immune. It was found necessary to heat the carburettor in order to vaporize the mixture. Good acceleration and flexibility were obtained, whilst starting was not difficult. There was a noticeable absence of "pinking."

Discol.—A commercial alcohol mixture fuel is that known as *Discol.* Its application in automobile engines permits the use of higher compression ratios, with corresponding power increases. When using this fuel in a carburettor designed for petrol, it is necessary to increase the size of the jet by about 20 to 25 per cent. The mixing chamber should also be exhaust-heated.

"Anti-Knock" Fuels.—It has already been shown that certain fuels such as alcohol and benzole do not exhibit any detonation effects when used in engines designed to run on petrol. By adding either of these fuels to petrol, the tendency to "knock" on full loads is lessened, due to the higher "safe" compression pressure resulting. Similarly if one of the *Aromatic Series* of liquids be added to pure petrol, a similar result will be obtained. Such fuels are known as "Anti-Knock" fuels, and their employment enables higher compressions to be used, and higher power outputs to be obtained. There is another class of anti-knock fuel obtained by adding a very small percentage of another liquid, such as *tetra-ethyl lead, ethyl iodide, aniline* (derived from coal tar), or xylidine, to petrol or benzole; the safe compression is raised considerably, and the tendency to "knock" reduced. Certain of the aromatic fuels, such as toluene, benzene or xylene, cannot be made to knock even with compressions of 180 lb. per sq. in.; these liquids can be added to petrol or benzole and will extend their compression range in proportion to their content.

Tetra-ethyl Lead Petrol.—The "anti-knock" value of the chemical substance known as tetra-ethyl lead upon petrol is now fairly well known. Among the numerous chemicals that can be added to petrol to produce this "anti-knock" effect, the one mentioned is about the most convenient from the commercial point of view.

It has been shown that very small proportions of tetra-ethyl lead in petrol suffice to prevent detonation.

Thus one part in 1,500 parts of ordinary petrol enables a compression ratio of at least 6·0 (according

to the combustion chamber design) to be used. It gives an appreciable power increase over ordinary petrol. Larger proportions of tetra-ethyl lead enable even higher compression ratios to be employed.

The commercial form of this "anti-knock" petrol is known as "Ethyl." It was originally manufactured by the Ethyl Corporation of America, but is sold by one of the large British oil concerns in this country.

The commercial form has a red appearance to distinguish it from ordinary petrol.

In addition to petrol it contains *tetra-ethyl lead* (a colourless liquid), *ethylene dibromide* and *halowax oil.*

The second constituent is used to prevent the lead from forming lead oxide and depositing in the engine as a solid instead of passing out of the exhaust. The halowax oil is to prevent gumming of the valve stems.

Acetylene as a Fuel.—This is a gaseous compound of carbon and hydrogen (C_2H_2) containing about 92½ per cent. carbon, and 7½ per cent. hydrogen. It has a heating value of 21,600 B.T.U.'s per lb. Mixed with air it has a wide explosive range, namely from 1 volume to from 4 to 18 volumes of air; the mixture for complete combustion contains about 12 volumes of air to 1 volume of acetylene gas. This mixture explodes violently, and if used in petrol engines detonation usually occurs. The engine parts require to be much stronger on account of the higher pressures developed. By bubbling acetylene through petrol, a "carburetted" gas results which has excellent combustion properties. If used in place of coal-gas, the gas consumption is only about one-third that of the former.

Acetylene is obtained by adding water to calcium carbide (CaC_2) when the gas is evolved. About 4½ cu. ft. of acetylene are produced per lb. of carbide. It can be obtained dissolved, or absorbed in a solution of acetone in a porous matrix, at about 150 lb. per. sq. in. pressure, under the name D.A. (dissolved acetylene).

Octane Value of Fuel.—The use of various fuel mixtures and "doped" petrols in high compression engines has necessitated the provision of some standard of reference, whereby the anti-knock rating of each fuel can be compared.

The standard fuel adopted for this purpose has two constituents, namely, *iso-octane* and *heptane*. The former is a fuel that has a higher anti-knock value than all the fuels hitherto used in petrol engines. Heptane, on the other hand, is a very poor fuel giving definite "knock" properties.

For these reasons iso-octane is taken as the upper standard of comparison and given the arbitrary value of 100, whilst heptane is zero.

Any fuel can have its anti-knock properties assessed by taking the equivalent proportions of iso-octane and heptane which give the same anti-knock properties in a standard test engine. Thus if it is found that a mixture of 75 parts of iso-octane and 25 parts of heptane give identical anti-knock results to that of the fuel tested under the same conditions in the test engine the fuel in question is said to have an *Octane number of* 75.

It is customary in official fuel specifications to state the octane rating and it is significant that whilst the octane numbers of ordinary commercial vehicle fuels range from about 65 to 70, those for anti-knock petrols, such as Ethyl petrol vary from 74 to 85. Aircraft fuels have higher ratings, for it has been shown that *the power output from a given capacity engine increases with the octane rating of the fuel* used, provided the most suitable compression is employed. In this connection the Air Ministry D.T.D. 230 Specification fuel has an octane rating of 87, but fuels of 100 octane number are used in recent engines.

Oetane Value and Power Output.—The power output from an engine having cylinders of fixed bore and stroke can be increased by using a fuel having a higher octane value. In order to obtain this result it is necessary to raise the compression, this increase being possible on account of the reduced tendency of the

engine to detonate with its previous compression ratio. As the latter is increased the brake mean effective pressure and also the maximum cylinder pressure also increase, so that the horse power from a given capacity engine can be raised, progressively, as the octane value of the fuel used is increased.

Fig. 5 illustrates how the octane value of motor car engines has increased during the period of years shown by the abscissae scale and Fig. 6 indicates the corresponding increases that have been made in the compression ratios, B.M.E.P.'s, horse power per unit capacity (cu. in.), etc., in the case of American automobile engines.

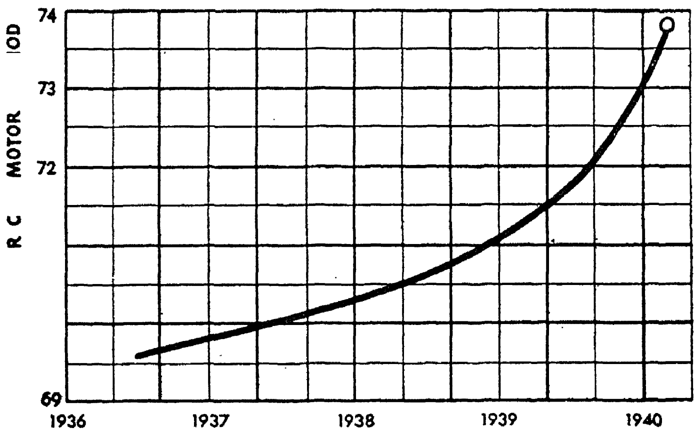


Fig. 5.—Showing Progressive increase in Octane Value of Automobile Engine Fuels.

In practice there is a limit, in the case of unsupercharged engines, to the greatest compression ratio that can be employed, before the cylinder maximum pressures become excessive, i.e., before the weight of the engine must be increased appreciably in order to obtain the greater strength necessary to withstand these high cylinder pressure loadings.

The present unsupercharged compression ratios for fuels up to 80 octane values vary between 6 : 1 and 7 : 1. With octane values of 80 to 100 compression ratios up to 7·5 : 1 have been used on aircraft engines. In order

to obtain the best results from the use of higher octane fuels without excessive cylinder pressures, super-charging must be employed.

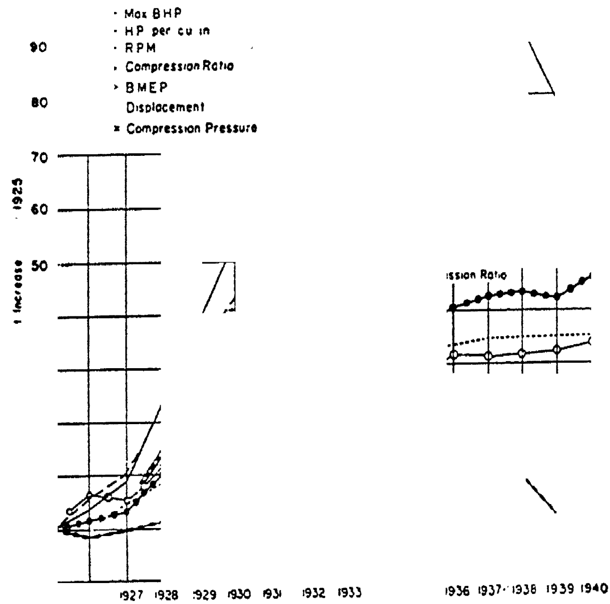


Fig. 6.—Improvement in Performances of Automobile Engines over Fifteen Year Period.

As the octane value and corresponding compression ratio increase *the fuel consumption* per horse power per hour is reduced progressively, as shown by the results given in the following table:—

Compression ratio	4·0	4·5	5·0	5·5	6·0	6·5	7·0
Fuel consumption per B.H.P. per hour. *	0·55	0·515	0·485	0·465	0·445	0·435	0·420

Minimum values for single cylinder test engine using most economical mixture strength.

CHAPTER III

THE SIMPLE CARBURETTOR

Previously the various theoretical aspects of the subjects of combustion, fuels and internal combustion engine explosive mixtures have been considered, without considering the means for obtaining, maintaining (under various conditions of load, speed and other factors) and regulating the mixture. It is proposed now to devote some space to a consideration of the more simple devices—*carburettors* as they are termed—for attaining these ends, and to point out the failings of these, and the remedies available for their successful practical working. Having then discussed the principles of the simple and modified carburettors, some of the representative types of commercial carburettors used in this and other countries will be described.

What the Carburettor Does.—A carburettor is a device for supplying the explosive mixture of air and (liquid) fuel, in the correct proportions for proper combustion, to the inlet pipe of the engine. The fuel in most automobile carburettors is not actually vaporized, but is supplied in the form of a spray or cloud of fine liquid particles, and in that form is mixed with the necessary quantity of air, and drawn into the engine cylinders, in virtue of the suction created by the descending piston on the inlet stroke (in four-cycle engines). This type of fuel-air mixing device is termed a *Spray Carburettor.*

In the early days of the motor-car, another type was very popular, namely the surface or *Wick Carburettor;* in this type the petrol or benzene was drawn up lamp wicks from a reservoir, and the fuel was actually vaporized by drawing hot air over the surface of the carburettor.

The spray carburettor must supply the proper quantity of petrol in atomized form, mix it with the correct amount of air, and regulate the quantity of mixture thus formed, to suit the load requirements of the engine. It must also supply the correct proportions of air and fuel to enable the engine to start up readily from the cold, to run slowly (when the vehicle is stationary) to work over a wide range of engine speeds (from about 300 to 4,000 r.p.m. in modern engines) and engine loads. Thus it should give the correct mixture under the following diverse conditions: (*a*) When the engine is on full load, at a moderate or low speed. (*b*) At full speed on partial loads. (*c*) At full load and full speed. (*d*) At light loads and low speeds. (*e*) In very cold and also very warm climatic conditions. In spite of the numerous available designs and varieties of commercial carburettors, at present, none entirely fulfils all of these conditions, automatically and economically, although much progress has been made in recent designs.

The Simple Spray Carburettor.—The modern spray carburettor in its various forms has been evolved from the elementary simple jet type of carburettor shown in Fig. 7, consisting of a fuel jet of small diameter placed in a constricted tube, known as a *Venturi* or *Choke-Tube*. The suction created by the descending piston of the engine cylinder to which the inlet pipe is connected, draws a certain quantity of air through the *Main Air Supply* pipe, at a velocity depending upon the relative areas of the piston and air pipe. An idea of the usual order of the air speed at entry in the carburettor can be obtained when it is stated that in the case of a cylinder of 3in. bore and 4 in. stroke the air inlet diameter will be about 1 in., and at 2,000 r.p.m. the velocity of the entering air will be about 200 ft. per second (or 136 miles per hour). Just opposite the fuel exit hole in the jet is placed the constriction; the diameter of this opening is usually one-half that of the air or inlet pipe. The effect of this choke-tube is to increase the velocity of the air to about four times its previous value,* namely

* The air velocities vary inversely as the squares of the pipe diameters within certain limits.

to about 800 f.s. Now, when the velocity of air is increased in this manner, its pressure falls; in other words a partial vacuum, or suction effect is created in the choke-tube. Since, also, the surface of the fuel in the float chamber is exposed to atmospheric pressure, whilst at the jet opening (in the choke-tube) the pressure is less than this, it follows that fuel is

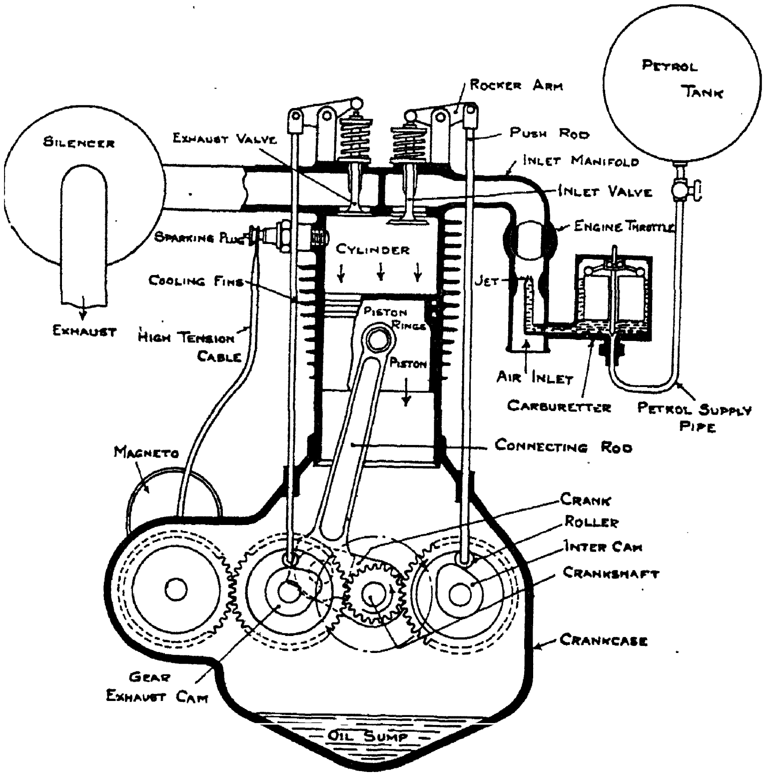


Fig. 7—The Carburettor Unit attached to the Engine.

forced out of the jet due to this pressure difference, where it mixes with this high velocity air, being atomized in the process, and passes with it into the engine *via* the inlet or induction pipe and inlet valve; the latter is very hot and therefore vaporizes most of the fuel spray cloud. Where heavy petrols, or petrol-paraffin mixtures are used, this vaporization process is assisted by causing the mixture from the carburettor

to impinge upon a portion of the inlet pipe, the outside of which is heated by the exhaust gases; this heated portion of the inlet is usually known as the *Hot Spot*; it is also used in several petrol carburettors.

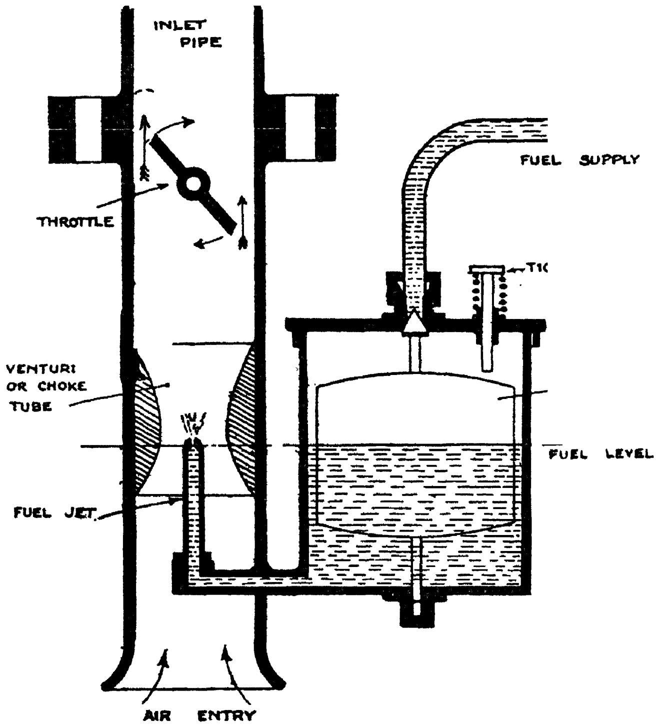


Fig. 8.—Simple Carburettor and its Components.

The jet orifice is very small indeed in comparison with the choke-tube area; thus for a choke-tube of $\frac{3}{4}$ in. diameter the diameter of the jet orifice usually lies between $\frac{1}{25}$ and $\frac{1}{50}$ in. The small weight of liquid fuel issuing from the jet forms a relatively large volume of vapour, however. In this connection it is of interest to note that the quantity of petrol used per revolution of an automobile engine developing 40 H.P. at its normal speed of, say, 2,000 r.p.m. is only about $\frac{1}{4500}$ part of a pint.

Let us next consider how the fuel is supplied to the simple jet. The fuel is led by gravity from the fuel reservoir to the top of the cylindrical chamber known as the *Float Chamber*, which contains a hollow thin metal float,* provided with a central conical needle above, so arranged that when sufficient fuel enters the float chamber the float is lifted, due to its buoyancy, and the conical needle valve engages with a similarly shaped seating in the petrol pipe union, and thus shuts off the fuel. In this manner the fuel in the float chamber is maintained always at the same level; if the level tends to fall, the float drops and thereby opens the needle valve, thus admitting more fuel. The level of the fuel in the float chamber is the same as that in the jet, i.e., nearly level horizontally with the top of the jet, but a trifle below. In this way the flow of fuel from the jet is regulated only by the suction created by the high velocity air in the choke, and not by any difference of level due to the fuel in the float chamber, assuming the carburettor is stationary.

The Simple Carburettor Control.—The mixture supplied to the inlet pipe and engine is regulated in amount to suit the load on the engine by placing a variable opening device, termed the *Throttle*, between the carburettor and the engine, usually just above the jet. There are two principal types of throttle, namely the circular disc, or *Butterfly Valve*, and the rotating cylinder type, having a transverse circular orifice of the same diameter as the inlet pipe, and known as the *Cylindrical Valve*. The latter is considered to be better than the former, since it gives the full unobstructed pipe opening, when fully opened; the former always reduces the pipe area, and a certain loss of quantity of mixture, due to friction and eddying, occurs at high speeds and in the full load position. The throttle is provided with a short lever, which can be operated by means of suitable rods, or cable, from the driver's seat, in order to regulate the speed or load of the engine. Usually the controls consist of a foot operated pedal, known as the *Accelerator*, which when

* In some American carburettors the floats were made of cork, varnished so as to protect them from the action of the fuel.

depressed opens the throttle, and a *Hand Throttle Control Lever* on the steering column, or dashboard. The latter control is used for regulating the slow running position of the throttle in the carburettor for starting and adjustment purposes. It usually operates quite independently of the foot pedal, but is arranged to limit the return position of the latter; thus if the hand throttle be adjusted so that the engine will run at a certain speed, the foot pedal always starts from and returns to this position (and speed). In effect the hand throttle movement controls the position of a stop against which the foot pedal returns when released. Practically the whole of the speed and load regulation of the engine, when the vehicle is on the road, is done on the accelerator.

In addition to this main control, modern carburettors, for reasons which will be considered later, are provided with controls for independent enrichment or weakening of the mixture, operated either automatically or by the movement of a knob control, from the driver's seat.

Many heavy commercial vehicles are also provided with automatic means, in the form of a governor, for limiting the maximum speed of the engine; in some cases the speed is maintained uniform, but the governor can be cut out of action if required. A typical centrifugal type of throttle governor possesses an auxiliary throttle which is closed when the speed exceeds a certain value, by the centrifugal action of the rotating weights; these fly outwards at a predetermined speed, and operate the throttle closing mechanism.

Other Types of Float Mechanism.—In addition to the simple form illustrated in Fig. 8, there is another very popular type of float mechanism, shown in Fig. 7, which consists of the usual float, above which is a pair of pivoted levers, with their hinge pins on the float chamber lid; these levers are purposely made heavier on their outer ends. The inner ends of the levers engage with a two-flanged collar which is secured to a central rod terminating below in a conical point; the latter acts as the "shut-off," or

needle valve. The rod passes through the hollow float tube, and also takes a bearing in the float chamber cap. In this case the petrol enters at the lowest part of the float chamber, thus leaving the lid quite clear and accessible. When the fuel level falls the float drops, and the heavier outer ends of the levers drop, thus forcing the other ends, and also the collar and needle valve upwards; fuel then flows into the float chamber, and the float rises until the inner ends of the levers are moved sufficiently far downwards to shut the needle valve.

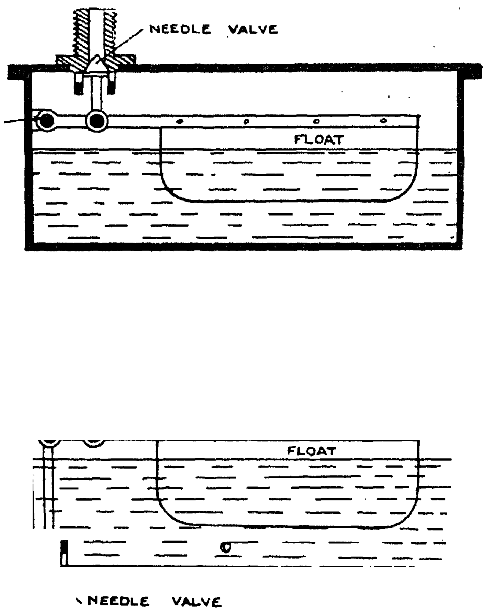


Fig. 9.—Two Alternative Types of Float Mechanism in use on Carburettors.

In this case the *level of the fuel* in the float chamber can *be raised* by unsoldering (if the collar is soldered) or tapping the needle collar *downwards*, i.e., towards the tapered needle valve. The converse direction is used for lowering the fuel level.

In certain American carburettors a simple form of cork float affixed to a metal lever, hinged at one end (as shewn in Fig. 9), is employed; in this case the

fuel enters from the top of the float chamber. If it is desired to lead the fuel to the base of the float chamber, the lever in question must be pivoted at its centre, the valve being on the other end, and opening upwards.

When *heavy fuels*, such as alcohol, benzole or paraffin are used in place of petrol, the *level* of these fuels will be *lower* in the float chamber and also in the jet. A smaller volume of fuel will therefore be drawn into the engine, and it will depend upon whether the fuel requires more or less air than petrol, as to the desirability of raising the fuel level, by weighting the float (so as to cause it to sink) or by moving the needle valve collar downwards (in the example of Fig. 33) or of leaving the level lower.

Diaphragm Controlled Petrol Level.—Whilst the float method of controlling the fuel level has been used extensively in automobile and aircraft engines in the past, it has certain disadvantages, the principal one of which is that of the inertia of the float which causes the needle valve to open and shut when the vehicle is jolted on bad roads, thus causing a loss of fuel and undue wear of the float mechanism. The hollow type metal float is also liable to puncture after an appreciable period of usage.

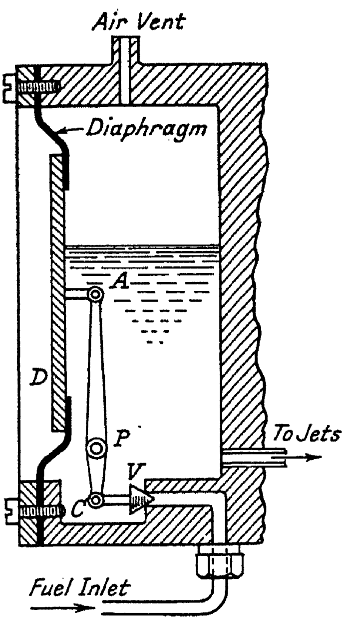


Fig. 10.—Diaphragm Method of Controlling Fuel Level in Float Chamber.

In the case of aircraft carburettors the evolutions of the machine may cause the float to experience certain acceleration and deceleration effects which may occasion the float mechanism to operate independently and thus to alter the

mixture or to cause flooding—or even stopping—of the engine.

To overcome these drawbacks a diaphragm method of controlling the fuel level has been introduced in certain more recent models of carburettors, notably of the aircraft pattern. The principle employed is shown, diagrammatically in Fig. 10. One side of the fuel chamber is provided with a flexible diaphragm clamped around its edges and having a metal plate D for the central portion. A simple lever system is actuated by the movement of the diaphragm to open and close the fuel inlet valve V. The lever AC has a fixed position pivot P, such that when the fuel level rises to the predetermined height the weight of fuel causes the diaphragm to move outwards and thus to close the valve V. If, on the other hand, the fuel level falls the natural elasticity of the diaphragm causes it to move inwards and thus to open the valve V.

The "Ceco" non-icing carburettor fitted to Pratt and Whitney and also Wright aircraft engines employs this type of fuel inlet valve control.

Aero Type Float Chamber.—A special design of float chamber employed normally on aircraft engines is such that the body of the carburettor is completely

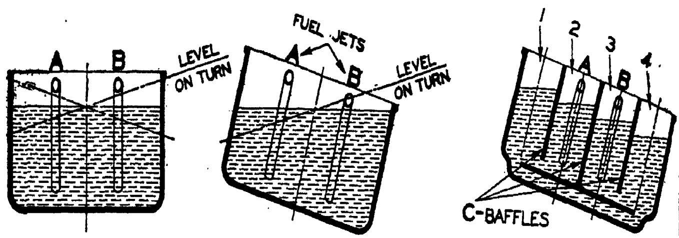


Fig. 11—(1) Ordinary float chamber with jets A and B, level.
(2) Ordinary float chamber, tilted, giving flooding of jet B.
(3) Effect of baffles C in preventing flooding of jets A and B in Aero type float chamber.

surrounded by it, so that the jet supply orifices or the jets themselves are arranged in the centre of the fuel supply; there is a float on each side of the carburettor

the two floats having a common mechanism controlling the needle valve; baffles are also fitted in the float chamber. The object of this type of float chamber (shown diagrammatically in Fig. 11) is to prevent surging of the petrol into the jets when the carburettor is suddenly accelerated or stopped, and when it is operating in the inclined position.

The Aero pattern float chamber described is now used on certain types of car carburettor, notably the Bendix-Stromberg models.

Defects of the Simple Spray Carburettors.—The simple jet and air supply tube carburettors described can be arranged, by carefully proportioning their areas, to work very well at any one speed, and to supply the correct fuel-air mixture at this speed. Let us consider, however, what happens when the speed of the engine is increased, say, by reducing the load, or by opening the throttle wider. The quantity of air past the jet will increase practically in proportion, but the quantity of fuel will increase at a greater rate. It can be shown, theoretically, that as the laws of flow for gases (air) and for liquids (fuels) are different, a given increase in velocity of the air will produce a proportionately greater flow of fuel; thus in a given example if the velocity of the air past the jet be doubled, the amount of air will also be doubled, whilst the quantity of fuel (in this case, petrol) will be increased by about 2½ times.

The net result of this will be to *enrich the mixture as the speed of the engine increases*, and to *weaken the mixture* as the *speed falls* below the correct mixture value. In the above example doubling the air speed will enrich the mixture by about 25 per cent.

It is evident, therefore, that the simple spray carburettor will only give the proper mixture at one speed; will give too rich a mixture at higher, and too weak a one at lower speeds.

Many of the earlier, and also some of the present motor-cycle carburettors are simple spray types, with auxiliary means for introducing additional air at the higher speeds, and for cutting off part of the air at lower speeds. A popular device, which was employed

on old cars is the auxiliary air valve fitted above the jet, but below the throttle. This device consisted of a flat, small poppet, or conically seated valve, opening inwards, held on to its seating by means of a light spiral spring. At low speeds the spring tension held the valve closed, but at the higher speeds the increased engine suction was sufficient to open the valve and thus admit more air to dilute the rich mixture. Means were provided, in the form of a milled screw and nut for altering the spring load, so that the amount of air admitted could be adjusted.

Starting Difficulty with Simple Jet Carburettor.—It has been shown how the mixture weakens as the air speed diminishes, and it will be evident that at very low speeds the mixture will be too weak in fuel to fire properly. As a result starting the engine would be impossible with the simple carburettor. To obviate this means can be provided for enrichment of the mixture sufficiently at low speeds, as follows:—

(*a*) By flooding the jet, so that an excess of fuel flows. Most carburettors are fitted with devices, known as "Ticklers," for depressing the float so that fuel drips from the jet; these devices are used for starting.

(*b*) By fitting a trap-door, choke or valve, to the main air intake, so that the latter may be partly closed for starting.

(*c*) By fitting an adjustable area jet. A simple method consists of a long tapered needle which can be screwed into the jet, as shown in Fig. 66. It may be operated either above or below the jet top; in the latter case, a liquid tight gland must be used. For starting, the needle valve is screwed away from the jet, so as to allow more fuel to flow.

(*d*) By providing a separate small jet in a small air tube, having its outlet to the engine just above the closed position of the throttle. In effect this arrangement is simply an auxiliary mixture device giving a rich mixture, which comes into operation when the throttle is closed, and ceases to function when the throttle

is open appreciably. This starting device is known as a *Pilot Jet*, and is a feature of most of the modern carburettors. Sometimes the increased suction due to the nearly closed throttle is made use of to provide a richer mixture for starting. In this respect it should be mentioned that *most engines will usually start better* with the *throttle nearly closed* than with it appreciably open.

(*e*) By providing a felt or asbestos pad in or near the main air intake and saturating this with a light spirit such as petrol. The petrol vapour will mix with the ingoing air and thus enrich the mixture.

(*f*) By direct injection of fuel into the inlet pipe or cylinders through a tap. There are devices on the market consisting of separate petrol reservoirs, jets and choke-tubes for giving a rich mixture for starting purposes; when the engine starts the device is switched off and the ordinary carburettor comes into action. (See Chapter XV.)

Acceleration Difficulty.—The simple carburettor suffers also from the drawback of "spluttering" or *weakening its mixture* when the *throttle is suddenly opened*, due to the inertia effect of the fuel which prevents the proper amount from flowing immediately. Modern carburettors are provided with special devices to counteract this tendency.

Weather Influences.—If the simple carburettor is set to work *correctly* at a given speed *in the winter months*, it will be found to give *too rich* a mixture in the *summer months*. This effect is due to the fact that the density of the air diminishes with the rise of temperature to a greater extent than in the case of fuels such as petrol and benzole, with the result that a relatively smaller weight of air is drawn into the engine; the mixture is therefore *weaker in air*, that is *richer in fuel*. The viscosity or fluid friction of the fuel is also proportionately less in summer so there is less resistance to flow, and more liquid flows

for a given suction on the jet. Most modern carburettors are provided with means for slightly altering the average, or working strength of the mixture, either by means of a variable fuel jet, or variable air intake. It is preferable to provide a graduated scale with these adjustments in order to note the particular settings in winter and summer, or in cold nights following warm days.

Altitude Influences.*—The simple, and also most ordinary, carburettors are affected by changes of atmospheric pressure. As the altitude at which the carburettor is used increases, the atmospheric pressure and air density diminish, with the result that there is proportionately less air (and therefore more fuel) in the mixture. This enrichening of the mixture with height above the sea-level, although of very little consequence in ordinary hilly country, is important where mountainous districts are concerned, and more important still in aircraft. It leads not only to a falling off in power at altitudes above 5,000 ft., but also causes a wastage of fuel. Thus a 10 per cent. over rich mixture in the case of a 400 H.P. engine means an hourly waste of no less than 2 gallons of petrol, and a consequent shortening of an 8 hours' flight to 7 hours. All aircraft carburettors are provided with an altitude control.

Load and Speed Variation Effects.—We have shown that the simple carburettor functions correctly at one speed only; it follows that it will only work at one engine load. Let us suppose, however, that compensating means such as an extra air control or a variable jet are provided, and are so connected to the throttle control that as the latter is opened, and the speed increases, the mixture remains correct over the whole range. This arrangement will give the required speed compensation. Consider next the effect of a sudden increase in the load on the engine, as when a motor vehicle reaches a hill. The throttle will be nearly full open, but the engine speed will be much lower than that which normally corresponds to this throttle position. The air speed past the jet

* See also Chapter VIII.

will be *much lower*, and *relatively less petrol* will flow, so that the effect will be to *weaken the mixture*, in spite of the speed mixture compensating device. Again if the engine load is suddenly reduced for a given throttle position, the engine will tend to race away, and more air at a higher velocity will flow, thus causing an *enrichment of the mixture*. Recapitulating, we see that

(1) *Running an engine under load at low speeds results in a weakening of the mixture.*

(2) *Running a lightly loaded engine at high speeds causes an enrichment of the mixture.*

A good example of the latter effect is in the case of a motor-car running downhill at a fair speed, with a small throttle opening; a much richer mixture results, and the fuel consumption is relatively heavier. It is here that the extra-air valve is useful. Several of the modern carburettors designed to give the correct mixture as the throttle is opened, and the speed increases, suffer from the above-mentioned defects.

Summary of Carburettor Requirements.—The preceding considerations of the simple spray carburettor enable us to lay down the ideal requirements for the automobile and aircraft carburettor, as follows: The ideal carburettor should:

(1) Supply correct mixture, properly atomised, at each speed corresponding to the throttle position.
(2) Provide correct mixture at each throttle opening, but under different loads and speeds.
(3) Provide easy starting from the cold.
(4) Enable the engine to run slowly without hunting or "missing", when "idling", without undue wastage of fuel.
(5) Give maximum acceleration when the throttle is suddenly or slowly opened, and be free from "flat spots" throughout the throttle opening range.
(6) Be so designed that when the throttle is fully opened the maximum quantity of correct mixture flows into the engine, there being no loss of

charge through sudden bends, restrictions or friction.

(7) Function correctly under different climatic conditions, such as temperature changes, barometric (or altitude) changes and atmospheric moisture variations.

(8) Give maximum mileage per gallon under above conditions.

Practical requirements indicate *good accessibility* to parts, such as the float chamber, jets and fuel filter; minimum number of wearing or working parts; ease of adjustments to parts requiring same; simplicity. It is an additional advantage if the carburettor is compact in size, can be readily adjusted from a dashboard control for mixture setting and can be modified in a simple manner so as to run on different fuels, e.g., petrol, benzole, and alcohol mixtures.

CHAPTER IV

TYPES OF CARBURETTORS

Practical Methods of Solution.—The account given in the preceding chapter of the faults and failings of the simple jet carburettor, which is the basis of design of most modern carburettors, will have indicated also the difficulties concerned in the design of a carburettor which will function correctly under all practical working conditions; it will also assist the reader to understand better the different methods adopted to attain these ends in commercial carburettors.

There are several alternative methods employed in order to obtain the correct mixture in automobile engines, working under various conditions. We shall refer briefly to the principles of these methods, and then proceed to describe some of the more representative commercial types of carburettor belonging to one or other of the following classes:

(1) The Hand-Operated or Automatic Separate Air Valve Class.

(2) The Hydraulic, Submerged Jet or Well Class.

(3) The Suction-Operated Compensated Jet or Choke-Tube Class.

(4) The Mechanical Compensation Class.

(5) The Multiple Jet Class.

There is a number of carburettors which employ a combination of two or more of these principles; examples of these will be referred to. In addition there is the surface or wick type carburettor, which was used on the Lanchester cars many years ago.

(1) The Hand-Operated or Automatic Air Valve Type.—In this type, the simple jet principle is followed for the main mixture supply, with the addition of an extra-air valve, which may be operated by hand, as in the Bowden wire-operated air valves, or slides of

many motor-cycle carburettors, or may be arranged to open by engine suction, as in the case of the automatic air valve shown in Fig. 17. In the former type it is left to the driver to regulate the mixture to suit the road conditions. Generally speaking, he will close the air lever for starting purpose, and will reduce the air opening for traffic running, when negotiating hills at low or moderate speeds, and in cold weather. For higher speeds, running downhill and in hot weather, the air lever will be opened more than usual. The automatic air valve compensation may be regarded as a compromise only; it gives only partial correction for the enrichening of the mixture. In most cases an impoverishment occurs at the highest speeds.

Depending as it does upon the quality of the engine suction, and upon spring control, the automatic air valve type cannot be considered a satisfactory single means of mixture compensation; moreover, it requires an auxiliary starting device.

(2) The Hydraulic, Submerged Jet or Well Type.—This principle, which is employed on a number of well-known carburettors has been shown to give satisfactory results. The method adopted consists in employing, in addition to the main jet M (Fig. 12) of the simple carburettor, another quite separate jet C alongside or concentric with the main jet. The jet C, as will be shown, acts as a Compensator to the main jet M, supplying a weak mixture when the engine speed is high, and the jet M is providing too rich a mixture, and enrichening the weak mixture supplied by M at low speeds. Fuel is supplied to C, from a reservoir or " well " W open to the atmosphere, which in turn is supplied through a restricted pipe or orifice R, from the float chamber F of the carburettor. The orifice R is so proportioned in area that it will only supply fuel at a certain rate; if the engine section on C withdraws fuel at a greater rate than R can supply it, the fuel level in C sinks and the fuel drawn from C becomes less.

Let us now consider the action of this two-jet carburettor. As we have already seen, the main jet M if adjusted to give a correct mixture at the normal

working speed will give too rich a mixture at high, and too weak a mixture at low speeds. On the other hand, at high speeds more fuel will be drawn from the jet C than the restricted orifice R can supply in time, with a result that the fuel level in C falls, and less fuel flows from the jet C than at normal speed. In this way the surplus supply of fuel from jet M, due to the high speed, can be counteracted by the reduced supply from jet C. Putting this in another way, whilst the mixture supplied by jet M enrichens, that from jet C weakens, or impoverishes, with a result that the average mixture remains constant in strength.

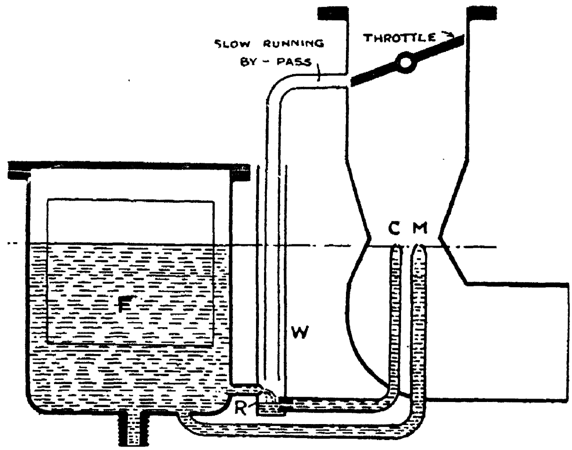


Fig. 12.—The Hydraulic Type Carburettor.

Similarly at low speeds jet C provides a surplus of fuel, as R can supply an ample amount of fuel for the purpose, whereas jet M gives a reduced supply due to the reduced air speed in the choke-tube; the two jets together therefore tend to supply a uniformly proportioned mixture.

Although there is a number of well-known carburettors which utilize the submerged jet principle, it is not easy in every case to trace out the practical interpretation in the design.

The principle outlined can also be illustrated by considering the simple graphs of fuel flow shown in Fig. 13, and in which distances from OY parallel to OX represent engine speeds, and those parallel to

OY quantities of fuel drawn into the engine from the carburettor jets. Within the working limits, the quantity of fuel drawn from the jet increases proportionately to the engine speed, or in other words the curve of fuel flow and speed is a straight line.

The ideal carburettor would give the line OP, passing through the zero speed and quantity point O. The actual line given by the single jet carburettor is that represented by the line ABC. At A (i.e., low speed, or starting) no fuel is supplied and up to the speed represented by OB¹ the quantity of fuel is insufficient (i.e., the mixture is too weak). At B only is the quantity of fuel, and therefore the mixture strength correct. At higher speeds, the portion of the graph BC lies above O B P, thus showing that the mixture is too rich in fuel. The curve ABC applies to the main jet M of Fig 12. Now the compensating jet C (Fig, 12) gives a curve such as A¹BC¹, indicating a surplus of fuel from zero to the speed OB¹ and a deficiency which becomes more enhanced as the speed increases beyond OB¹. The average flow of both jets C and M gives the correct line OBP.

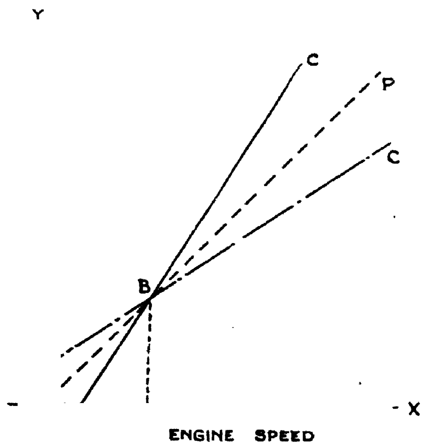


Fig. 13.

(3) The Suction Controlled Compensating Device.—There is a number of carburettors on the market which contain a movable element, in the form of a variable jet, air supply, or choke-tube, the movement of which is controlled by the degree of engine suction, or vacuum in the inlet pipe. This partial vacuum increases in value as the engine speed increases. A common arrangement is to employ a sliding piston or a bellows with a light spring control, near the choke-

tube portion of the carburettor, and to so arrange matters that as the engine suction increases (with engine speed) the piston or bellows is caused to move in a given direction, thus increasing the choke-tube, or reducing the effective area of a variable fuel jet; in the latter case the usual needle valve control can be connected up with the moving piston or bellows. Another method is to allow the latter to open an extra air valve as the engine speed increases.

In the case of the S.U. carburettor there is a suction-operated piston with tapered needle valve attached, the former element moving so as to increase the choke-tube area and also the jet area; there is a needle valve fixed axially to the piston for this purpose. The earlier Wolseley carburettor employed a bellows which operated a piston attached to the needle valve.

(4) The Mechanical Compensation Type.—This class includes quite a number of carburettors containing devices which are intended to maintain the mixture strength constant as the throttle is opened or closed. The usual arrangement consists in linking up the throttle with an air valve, or with the jet or choke-tube in such a way that the movement of the throttle regulates either the air or fuel supply, or the choke-tube area. Thus in one type the throttle is interconnected with the jet needle valve by means of a cam movement such that any desired regulation of the fuel supply is possible; in one or two cases the throttle is also connected up with one of the two air supply intakes, so that engine starting is rendered easy.

On the other hand, there are carburettor types which employ a specially shaped cylindrical throttle velve, so that when the throttle lever is closed, there is left a very small choke-tube area, to give a richer mixture for starting and slow running. As the throttle is opened, in virtue of its peculiar shaping, it varies the effective choke area in such a way as to keep the mixture constant.

In some instances the interconnected throttle device is combined with the submerged jet or well principle, so as to obtain a finer adjustment of mixture strength, and hence better fuel economy.

In reviewing the mechanical type described, namely in which the one movement of the throttle lever controls the air and (or) the fuel supply by an interconnected mechanism, it should be pointed out that whilst in general it gives approximately the correct mixture as the throttle is opened and the engine speed increases accordingly, yet it does not give the correct mixture at different speeds for the same throttle opening. It is necessary to provide an additional air or fuel control for this purpose.

(5) The Multiple Jet Type.—Although, strictly speaking, this type belongs to the general class described under the third heading, yet it has its own particular characteristics which merit its inclusion in a special class.

To understand the principle of this type imagine the engine to be supplied with mixture from several small carburettors in such a way that for starting and at low speeds one carburettor only (adjusted only for these conditions to give the correct mixture) is used. When the engine speed reaches a certain value, imagine a second carburettor to come into operation, giving a rather weaker mixture to compensate the increasing richness of the mixture from No. 1. Again, when the engine speed attains a still higher value let a third carburettor come into action, and so on until at full speed, all the carburettors are in action, and the combined mixture from all of these is correct over the last part of the speed range. In this way by arranging for each little carburettor to supply a compensating mixture over a part of the speed range it is possible to maintain an approximately correct mixture over the whole range. The principle described is carried out in practice by having a number (usually three, five or seven) separate jets each in its own choke-tube or compartment, and all fed from the one float chamber. The outlets from the respective choke-tubes to the inlet pipe are all at different levels, relatively to, say, the base of the float chamber or of the jets, No. 1 being the lowest, and the last number jet the highest. These outlets are opened or closed in turn, as the engine speed increases, or decreases, respectively, by means of a sliding piston,

slide, or sleeve, operated by the engine suction; thus as the engine speed increases, the increased suction in the carburettor causes the piston, slide or sleeve to move so as to uncover in turn each of the jets.

The action of the multiple jet carburettor is not quite as simple as the above description indicates, for as the sliding element moves under the influence of the increased engine suction, the choke-tube area of each jet is enlarged; there is therefore a tendency for the mixture to weaken until the next jet comes into operation, so that one may regard each component

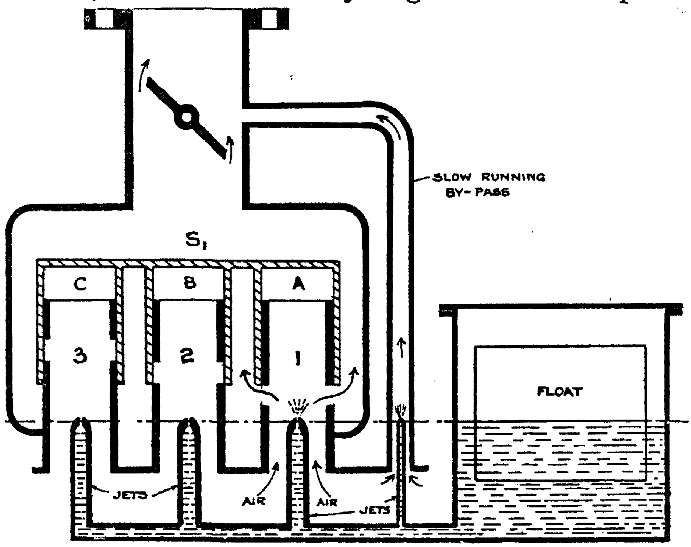


Fig. 14.—Illustrating the Principle of the Multiple Jet Type Carburettor.

jet and choke-tube to give a mixture at first rich, and then weaker.

Fig. 14 illustrates diagrammatically the principle explained. The sliding sleeve S may be regarded as carrying also three cylindrical sleeves A, B, and C, each being capable of sliding over its own choke-tube (1, 2 and 3 respectively). The orifice to the inlet pipe from No. 1 is the lowest and therefore the first uncovered by the sleeve A; the orifice No. 2 is next, and finally No. 3, when the engine speed, or suction, is sufficient to draw the sleeve S upwards to its fullest extent. In addition to the three jets and their chokes, shown,

there would also be the small pilot jet shown, the choke-tube of which would never be closed by the sleeve S_1 and which would communicate always with the space in the mixing chamber or inlet pipe, just above the "closed" position of the throttle. As the throttle opens, this jet is gradually cut out of action.

The Air Bleed Principle.—Several American carburettors use a system known as the "plain tube air bleed" one, in which atomization of the fuel is obtained by providing a small air leak, or "bleed," on the side of the main jet (as shown in Fig. 15A), but with the open end of the air leak tube

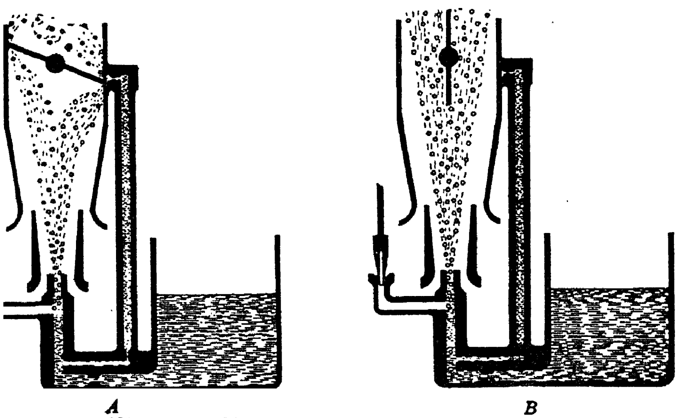


Fig. 15.—The Stromberg Carburettor.
A—Showing the Bleeder Principle; throttle closed. *B*—The Mixture Variation Device; throttle open.

above the jet level. The engine suction causes both petrol from the jet, and air (in the form of bubbles) from the "bleeding" device to issue into the mixing chamber. The principle of this method of atomizing is best illustrated by the experiment of sucking water up a tube from a vessel. If the tube is plain a continuous column of water will be drawn up, whereas if a small tube be inserted in the side of the other, below the liquid, and with its open end above the liquid, suction on the large tube will cause a finely divided emulsion to flow, with a much smaller amount of suction. The richness of the mixture in the case of the Stromberg carburettor is varied by altering

the "air bleed" orifice, by means of a tapered needle valve; the latter in the high speed position can be all but closed, thus enrichening the mixture. A fine hole (shown on the left in Fig. 15B) is left in the taper point to admit a much reduced supply of air for the richer mixtures. The carburettor in question contains a double or compound venturi tube, to assist still further in atomizing the fuel. As will be seen from the diagrams, there is a slow running, or idling passage, of the usual pilot jet type, with its exit near the closed position of the throttle.

As previously stated, the mixture variation is obtained by varying the position of the tapered air bleed "economizer" valve so as to alter the amount of air allowed to leak through. This valve is interconnected with the throttle so that it is regulated in position by the movement of the latter.

Certain models of this carburettor are also provided with an auxiliary fuel control needle valve device, operated from the dash, for enrichment of the mixture, for starting and other purposes. The slow-running tube is also provided with a mixture adjustment device. In a later model, an accelerating "well" is provided, consisting of an auxiliary "well" or supply of fuel which flows into the engine only when there is a low vacuum, or high engine load.

Combination Plain and Air Bleed System.—An alternative method to that described in the previous

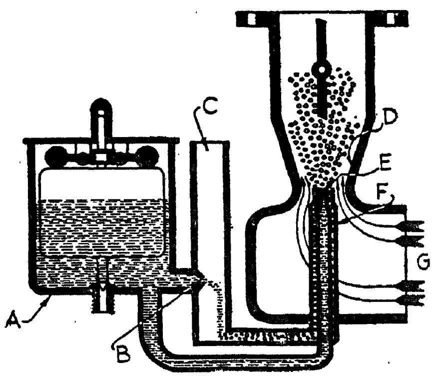


Fig. 16.—Combination of Plain and Air Bleed System.

paragraph is to employ an ordinary plain type of main jet E (Fig. 16) together with a concentric air-bleed jet. The tendency of the plain jet mixture to grow richer as the engine speed increases is then compensated by that of the air-bleed mixture to become weaker as the speed increases.

Referring to Fig. 16, the float chamber is shown at A, the metered petrol supply to air bleed system at B, the open air tube at C, the choke tube at E and the main air stream by the arrows at G. The air bleed supply to the jet is indicated by the small circles below, and the issuing mixture by those above the jets. The principle described is employed on the American Tillotson carburettors.

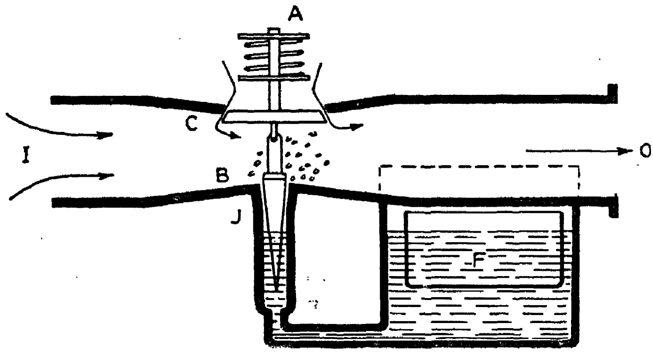


Fig. 17.—Mechanical Mixture Regulation.
A—Spring on Suction Valve C. B—Tapered needle in petrol jet J
F—Float. I—Air inlet. O—Mixture outlet to engine.

Mechanical Air and Petrol Metering System.—A method used on certain carburettors, including the Schebler, is to employ an automatic type of air valve which is attached directly, or through a suitable lever system, to a tapered needle valve in the petrol jet. As the engine speed increases the spring-loaded air valve opens under the suction action and the tapered needle moves into the jet so as to reduce the quantity of petrol emitted; in this way the mixture strength, which otherwise would increase in richness with engine speed increase is kept constant over the effective speed range. The action of this type is shown, diagrammatically, in Fig 17.

Typical Mechanical Metering Method.—In certain designs of carburettor, notably American ones, the amount of petrol delivered to the engine is measured or controlled mechanically by means of a needle valve or metering rod actuated by a mechanism connected with the main throttle.

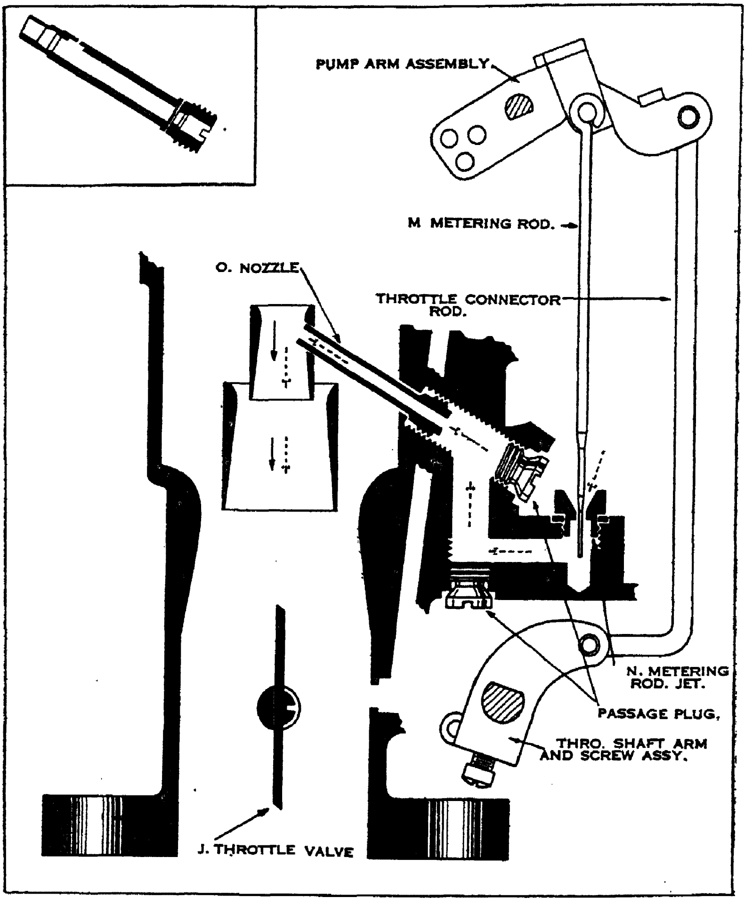


Fig. 18.—The Carter Carburettor Mechanical Metering Method of Mixture Control.

Fig. 18 illustrates the method of mixture control employed in the Carter carburettor for the intermediate and maximum power output requirements; the slow-

running section of the carburettor* has been omitted for simplicity purposes. The high speed circuit shown in Fig. 18 consists of the metering rod *M*, metering jet *N*, nozzle *O*, throttle valve *J*, throttle shaft arm, connector rod, accelerator pump arm assembly and metering rod spring. As the throttle is opened wide enough for a no-load speed of a little more than 20 m.p.h. the velocity of the air flowing through the carburettor throat causes a pressure a little less than atmospheric at the tip of the main nozzle. Under this slight suction effect petrol flows from the float chamber, through the metering jet, and out of the main nozzle into the throat of the carburettor.

As the speed increases above 20 m.p.h. the high speed system continues to come more and more into action and the idling system to be cut off; the latter system becomes inoperative at 30 m.p.h.

At higher speeds the area of the opening between the jet *N* and metering rod *M* governs the amount of petrol drawn into the engine. At top speed the smallest section of rod is in the jet and the maximum quantity of petrol flows out to mix with the maximum amount of air corresponding to full throttle opening.

Avoiding the "Flat Spot."—In certain types of carburettor having a pilot jet for starting and slow running, and a main jet for ordinary running, the pilot jet is usually given a rich mixture setting in order to avoid the unfavourable period which occurs as the throttle is opened suddenly, before the main jet suction becomes strong enough to supply a suitable mixture.

This inefficient period or "flat spot" in a carburettor is evident in the engine's response as a hesitation to pick up speed; in some cases the engine may actually stop.

Methods of avoiding the change-over effects mentioned include the use of throttle or priming pumps, bridging jets and smaller chokes. Most modern carburettors are fitted with such devices. A clever method of avoiding "flat spots" and obtaining continuous

* See page 66.

acceleration has been patented by Rolls Royce, Ltd. In this case the carburettor (Fig. 19) consists of a main straight air passage A containing a fixed choke tube B, into which fuel is delivered by a main nozzle C. There is an automatic valve D between the choke tube and the throttle valve E, a by-pass F around the automatic valve, and a choke G and subsidiary nozzle H in the by-pass. The valve D is operated by means of a piston J in a cylinder that is open at its lower end to the atmosphere, and at its upper end to the air passage

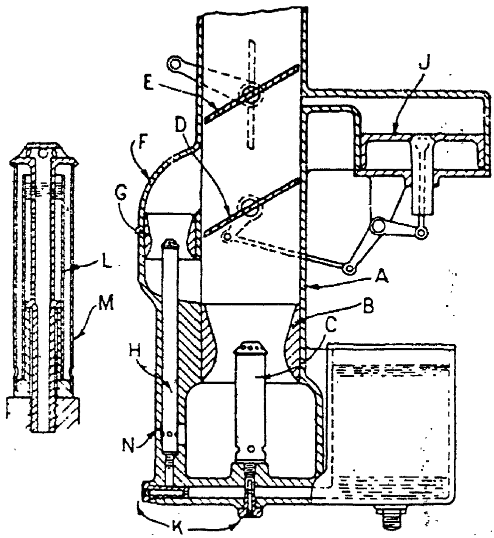


Fig. 19.—Showing one Method of avoiding the Flat Spot.

between the throttle E and the automatic valve D. Valve D opens only after some fuel has commenced to issue from the main nozzle, and metered plugs K control the flow of fuel.

A section of one of the nozzles is given on the left in Fig. 19, from which it will be seen that it consists of a central tube with rows of holes which lead to a space enclosed by a tube L. Tube L is surrounded by the tube M, opened at its base through holes to the air passage.

Starting and Slow Running.—All modern carburettors are provided with special means for starting from the cold and for slow running or idling purposes.

The method usually employed for starting is to shut off most of the main air supply to the main jets and to

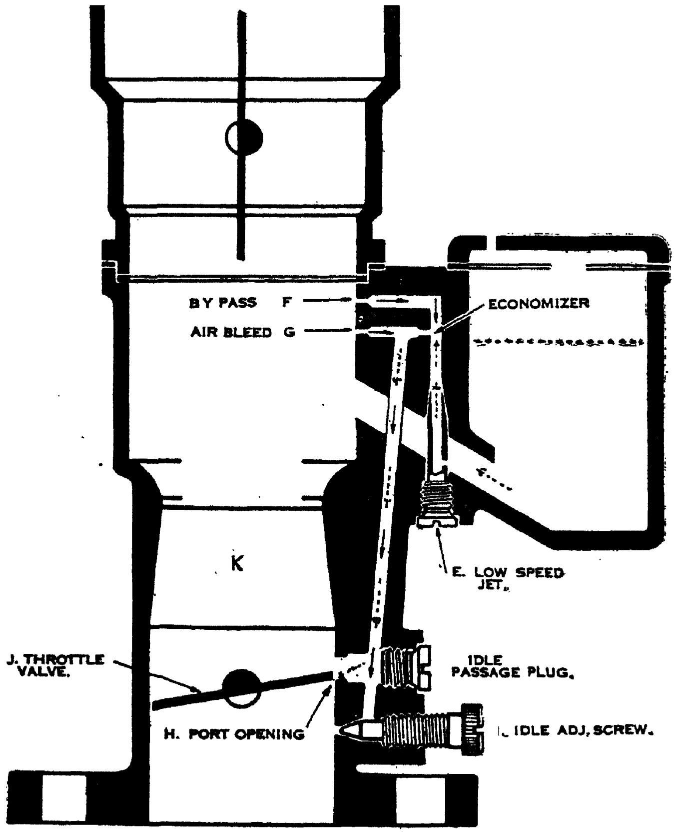


Fig. 20.—Starting and Slow Speed Mixture Control on Carter Carburettor.

operate the engine by means of an auxiliary carburettor device, embodied in the main carburettor. This commonly consists of a separate small jet and air supply which come into operation when the main

throttle is closed against its stop. The mixture from this "pilot" jet is supplied to the engine through a duct or passage which enters the carburettor main passage between the main throttle and the inlet manifold, thus, as it were, short-circuiting the main throttle.

The pilot jet or its air supply inlet are provided with an adjustment for altering the mixture strength in order to obtain the correct slow running performance.

Various types of starting and slow-running devices embodied in carburettors are described in the sections of this book that follow, so that it is here necessary only to illustrate a typical method, the example selected being the starting and slow running or low speed circuit of the Carter down draught carburettor (Fig. 20). In the illustration the main air supply is controlled by a butterfly valve, which is seen above; this valve is closed for starting, but is left open for slow running after the engine has warmed up.

The lower butterfly valve J is the engine throttle. The low speed jet E derives its petrol supply from the main float chamber and its air supply from the air port or by-pass F. An "air bleed" orifice G is provided for atomizing the petrol and the air-petrol mixture from E is drawn down the inclined passage in the direction shown by the arrow whence it passes around the edge of the throttle J through the port opening H and thence to the inlet manifold. The quantity of the pilot jet mixture can be regulated by the idle adjustment screw I, so that in this way the idling speed is controlled.

The Warming Up Process.—After the engine has started from the cold on its initially over-rich mixture, the mixture strength should be reduced gradually as the engine warms up. The period at which to reduce the mixture strength, in the case of engines fitted with hand-controlled air chokes, is indicated by the erratic running and tendency to stop. In most of the more recent carburettors described in this book automatic means are provided to open the air choke valve gradually as the engine warms up.

The warming up period, in the case of engines having thermostatically controlled cooling water systems is usually a matter of a few minutes at the end of which the engine will operate on its normal mixture strength, the air choke then being fully open. It should be mentioned that most carburettors derive heat for vaporizing the petrol or warming the air supply for initial running purposes after cold starting from the exhaust manifold, so that until the latter becomes hot the carburettor will not function in its normal manner.

Another indication of the incorrect use of the air choke, more particularly in cold weather, is the tendency of the engine to fire back through the carburettor when the accelerator is depressed; this is a sign of insufficient engine warming and, therefore, too weak a mixture. Under these circumstances the choke should be closed sufficiently to stop the back-firing. In most instances, however, gradual depression of the accelerator is advisable when starting the car from rest before the engine has warmed up sufficiently.

Automatic Chokes.—Hitherto the air choke has invariably been operated by hand, for engine starting purposes, a suitable hand control being provided on the dashboard, or near the radiator itself, in some instances. With the widespread use of motor cars by all classes of drivers, it became necessary to simplify the engine controls as much as possible, in order to relieve the driver of responsibility—and also to avoid the possibility of misuse—of such controls. It is well known that new drivers frequently forget to open the choke after starting—with consequent bad results to the engine cylinders and pistons and resultant heavy petrol consumption.

To obviate these drawbacks, it has become the practice on many cars to operate the air chokes automatically, for starting purposes—generally by the use of thermostatic controls actuated by the heat of the exhaust.

Thus, when the engine is cold the thermostat is arranged to hold the choke valve in its closed position, for starting. As the engine warms up the

exhaust heat causes the thermostat to open the choke gradually to its fully opened position.

Occasionally the thermostat is employed to operate the separate starting carburettor connection to the main carburettor, as in the Solex system, described later.

Another method is to employ a thermostatically controlled air choke, and in addition an electromagnetic device operated by the starter switch, such that when the engine is warm while being cranked the electromagnet will hold the choke valve wide open for starting, instead of only partly opened.

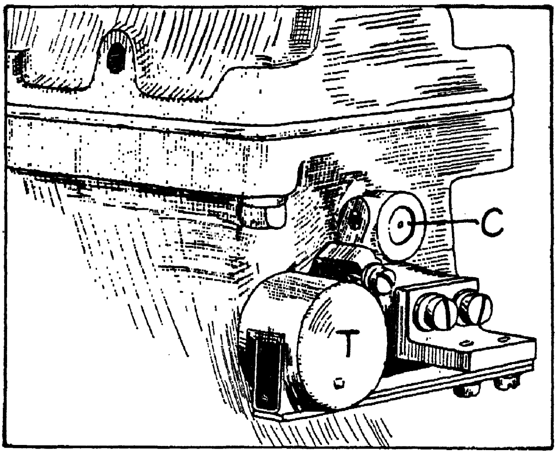


Fig. 21.—An external Thermostatic Control acting directly on Air Choke. T—Thermostat. C—Air choke butterfly valve shaft.

In certain American cars the automatic thermostatic choke is also supplemented by two other thermostats in the carburettor system; one for the automatic heat control and the other located between the throttle stop screw on the carburettor slow-running adjustment, and its stop. The purpose of this latter thermostat is to ensure an increased minimum throttle opening during the warming-up period. In one model Studebaker car, the engine is fitted with a down draught carburettor and automatic heat control. The latter feature is used in connection with an automatic choke. This combination relieves the driver of the necessity of hand

control of the fuel mixture while starting and during the warming-up period. The automatic choke is controlled by a bi-metallic thermostat located on the intake pipe. Heat control is entirely automatic and is effected by means of a valve in the exhaust pipe which is ordinarily closed by means of an unbalanced weight. A latch, ordinarily held in the closed position by a thermostatic spring, holds the valve closed until the engine has attained its working temperature. When this valve is closed, all of the exhaust gases from the engine are passed through the jacket on the intake manifold, which results in raising the intake manifold to the normal working temperature in a short time.

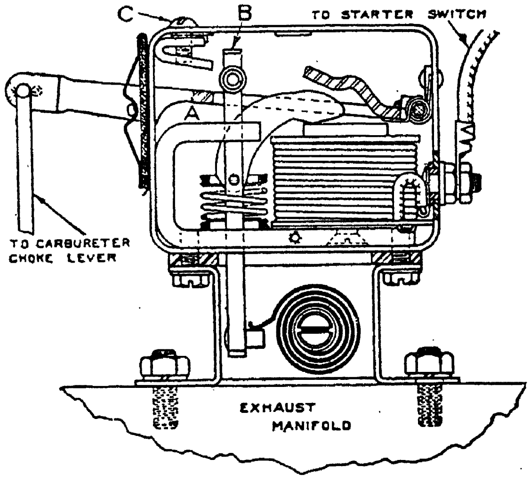


Fig. 22.—The Pierce Automatic Choke Device.

The thermostatically controlled heat valve then begins to open and to reduce the proportion of the exhaust gases passing through the intake jacket. At wide-open throttle very little exhaust passes through the jacket. The principal difference in comparison with former practice is that whereas formerly the heat was either all on or all off, now the supply of heat to the intake gases is regulated in accordance with requirements. During the warming-up period, in the same measure as the supply of heat to the inlet manifold is cut down, the richness of the mixture is reduced by the automatic choke.

Fig. 22 illustrates the Pierce automatic choke which has been fitted to several makes of American car. The choke-operating device comprises a bi-metallic thermostat and an electro-magnet, both enclosed in a metallic housing which is secured to the exhaust manifold. Two different types of the device are made, one for bolting to the top and the other to the side of the manifold.

The opening of the choke valve is controlled by the

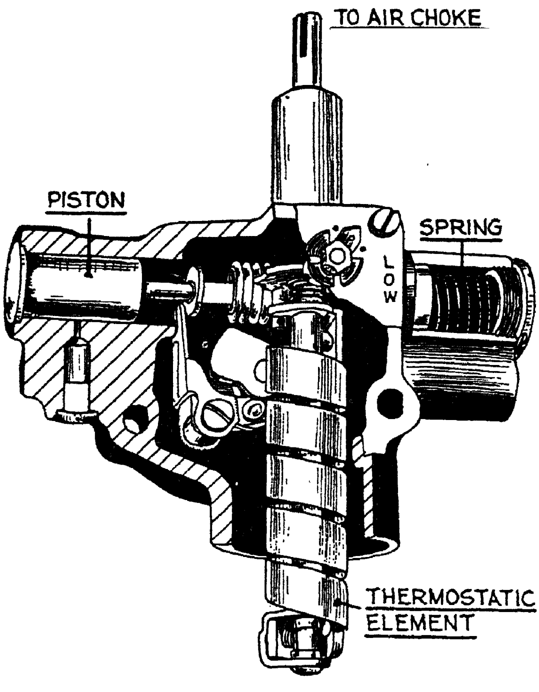


Fig. 23.—Thermostatic Choke Control fitted to Buick Carburettor.

thermostat. When the engine is started from cold, the choke valve will be completely closed. If the engine is warm while being cranked, the choke will be only partly closed; if the engine is hot, a magnetic lock positively holds the choke valve wide open for starting. The electro-magnet locking the choke in place is energized through the starting switch and is active only during the starting period, or as long as

the starter switch is closed. When the engine is in regular operation the thermostat controls the opening of the choke valve in accordance with the temperature of the exhaust manifold.

Referring to Fig. 22, illustrating the type mounted on top of the manifold, when the manifold is cold the bi-metallic spiral will coil up and pull the thermostatic control rod B down, closing the choke valve. As the manifold warms up, the bi-metallic spiral uncoils somewhat, allowing the coiled spring surrounding the thermostatic control rod to force that rod up, thus partly opening the choke valve. When the manifold is hot,

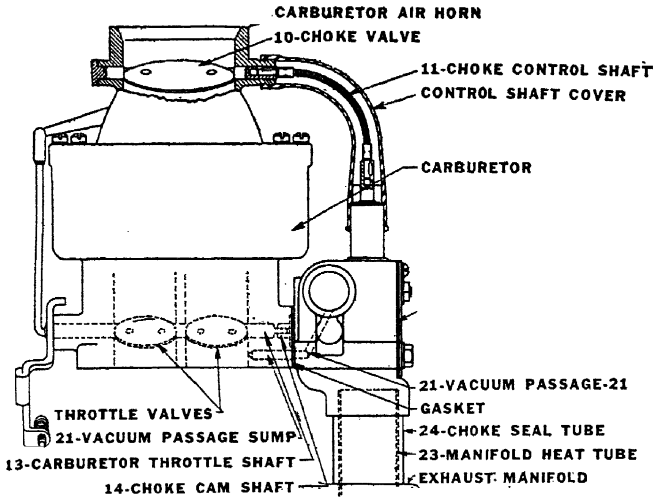


Fig. 24.—Showing Cable Operation of Air Choke Valve, in Buick Carburettor.

the spiral uncoils sufficiently to raise the control rod to the limit, and when the starter switch is then closed and the electro-magnet energized in consequence, the upper part of the control rod is swung by the electro-magnet to the left, into the locking clip C.

The automatic choke, in the case of the Buick engine (fitted with a Stromberg double-float carburettor of the dual down draught pattern) is illustrated in Fig. 23. It operates the air choke, which is of the usual butterfly valve type, by means of a short length of flexible cable attached at its lower end to the shaft seen at the top, in Fig. 24. The

choke control has a two-point adjustment for fuel volatility. It has also a spring and vacuum-controlled dashpot device. Heat is applied to the thermostatic helix from the exhaust manifold, there being a recess in the latter into which the lower end of the thermostat casing is fitted.

A special feature of this automatic choke is the provision of a device, whereby when the engine is warming up, the choke valve is slightly closed whenever the engine is suddenly accelerated, so that a richer mixture is provided; this device does not

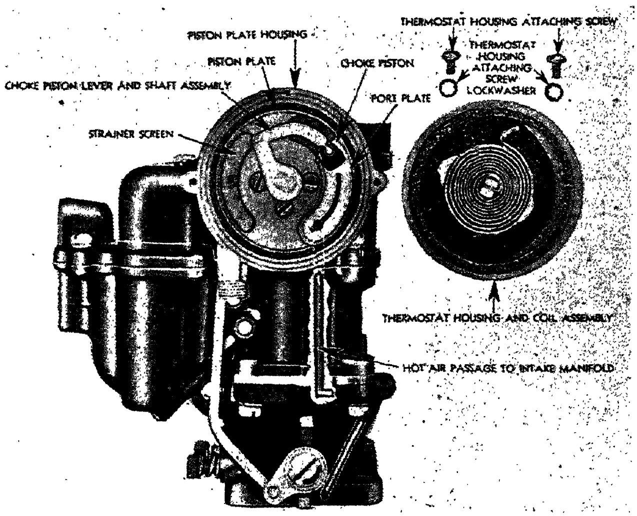


Fig. 25.—The Thermostatic Control used on certain Carter Carburettors.

operate, however, after the engine is fully warmed up.

The automatic choke control used on Carter carburettors fitted to certain American cars, of which the Oldsmobile is an example, is illustrated in Figs. 25 and 26. The thermostat takes the form of a bimetallic spiral spring, and it is heated by hot air from the inlet manifold. It incorporates a choke or damping piston device, and is in a heat insulated chamber. The carburettor in question belongs to the triple venturi dual down draught type, and is provided

with a climatic control on the thermostatic box for weakening or enrichening the mixture.

Later Choke Developments.—In the more recent Stromberg carburettors, several alternative forms of automatic chokes are available at the option of the car manufacturer. All of these operate, primarily as follows: (1) During cranking the automatic choke increases the throttle opening beyond that corresponding to normal idling and greatly enriches the mixture; (2) To keep the engine firing just after starting the increased throttle opening is maintained,

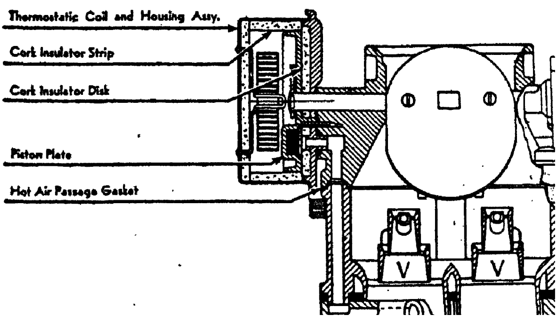


Fig. 26.—Sectional view through Head of Carter Carburettor of Twin Venturi Type, showing (on left) thermostatic control acting directly on air choke butterfly valve. The twin venturi tubes are shown at V.

but the mixture proportion is now changed to moderately rich; (3) As the engine warms up and its friction decreases, the throttle opening is reduced to the normal for idling; (4) During the warming-up driving period the mixture is very slightly enriched at part throttle but considerably enriched at full throttle; (5) As the engine approaches its minimum normal temperature the choke is opened fully, which gives a normal mixture proportion.

It will be noted that the above requirements involve

a co-ordination of throttle opening, mixture enrichment, and control according to engine load, which last is proportional to the manifold depression. Accordingly, *Stromberg automatic chokes employ a choke valve with its shaft off centre, so that it responds to suction (similar to the one shown in Fig. 26); a bi-metal thermostat spring, responsive either to engine temperature or a parallel temperature change, which opposes the opening of the choke valve as its temperature is lowered; and a "vacuum kick" piston, responsive to the depression beyond the throttle, which tends to help open the choke. While cranking, there is very little depression beyond the throttle, and the thermostat spring is set with enough tension to insure a very rich cranking mixture at low temperature. As soon as the engine starts to fire and speeds up, the resulting depression beyond the throttle operates on the "vacuum kick" piston to partially overcome the thermostat-spring effort, thus decreasing the mixture enrichment. As the engine warms up, the thermostat tension becomes less, decreasing the mixture enrichment; but all through this period, if the throttle be opened wide at low speed, the release of manifold depression tends to give a slightly richer mixture than at partial throttle opening. Finally, of course, the thermostat warms up enough to hold the choke valve wide open without the help of the "vacuum kick" piston.

A material improvement in control of the mixture during this warming up period has been obtained in the piston-type "fast idle", by making the "vacuum kick" piston the means of augmenting the throttle opening, and by having its motion also uncover an auxiliary "fast idle" fuel jet. In modern carburettor practice the metering suctions are quite low, which means that accurate control of the mixture by choke position is extraordinarily difficult, the scale of accuracy needed being of the order of a few thousandths of a pound-inch torque.

When the Stromberg "piston type" fast idle is fitted, the thermostat is adjusted so that during the warming-up period, the choke is so nearly open that

* Automotive Industries, 26/6/37.

its own enriching effect is negligible; a predetermined fast idle and mixture enrichment being obtained instead by air and fuel orifices uncovered by the fast-idle piston. This gives a powerful starting charge, along with a smooth warming-up mixture, not unduly rich; all without being sensitive to small variations in choke setting that are not controllable in production.

Electrically Heated Thermostats.—One interesting variation of the Stromberg automatic choke constructions is in the location of the thermostat elements. These were originally mounted on the carburettor in a location subject to heat conduction from the exhaust manifold; or, alternately, were heated by a tube bringing hot air from the exhaust manifold. In other cases they have been mounted

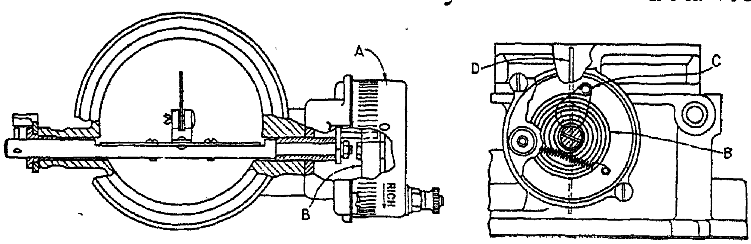


Fig. 27.—Electrically Heated Thermostat.

adjacent to the exhaust manifold. Another neat, compact and satisfactory approximation to ideal requirements has been obtained by mounting the thermostat spring directly on the end of the choke shaft and subjecting it to the heat of a small electric coil, drawing 0.9 to 1.1 ampere, and connected in series with the ignition switch. In this way, the choke valve action depends on both the initial hood temperature and on the time elapsed since the switch was turned on. This has proved quite satisfactory, and is particularly effective in getting the choke to open quickly, as is desirable with the very light petrols.

The arrangement of this thermostatic control is shown in Fig. 27. The thermostat B is of the bi-metallic coiled spring pattern with fixed inner end and the outer end of the spiral looped over the crank C on the end of the air choke spindle. The choke valve D is mounted in

an offset position on the choke spindle and it employs the usual Stromberg method of fast idle piston and linkage. The heat control arrangement consists of a spiral electric resistance element mounted in the insulated rear portion of the thermostat chamber A, one end being attached to an external terminal and the other earthed to the metal of the carburettor. The live terminal is connected by means of an insulated cable to the ignition live circuit so that the resistance heats up when the ignition is switched on, thus causing the thermostat spiral to operate by losing its tension. In this arrangement the electric resistance remains hot all the time the engine is running and cools down when the engine stops. The inner end of the thermostat

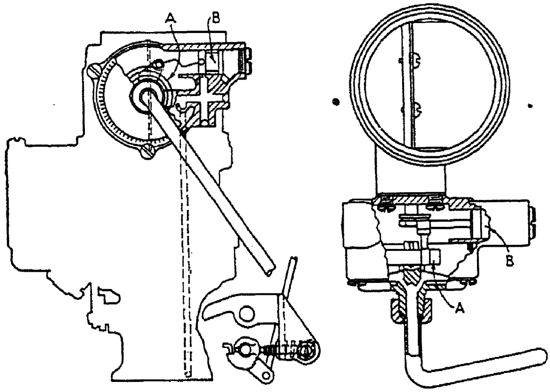


Fig. 28.—Hot Air Thermostatic Control.

spiral is attached to a peg in the chamber A which is held in position by means of two screws which clamp the flange of the chamber into place. The chamber is graduated on the outside and a pointer on the body of the carburettor enables the tension of the thermostat spiral to be varied in order to adjust the mixture strength for cold starting.

Hot Air Thermostat Control.—The later Stromberg carburettors employ a method of drawing heated air over the thermostat coils. The thermostat, in this arrangement is attached to the end of the air choke butterfly valve spindle and the small chamber enclosing the unit is connected to a heating unit or stove connected to the exhaust manifold by means of a tube, as

shown in Fig. 28.* Hot air from the stove is drawn through the thermostat chamber by means of passages cast in the carburettor whence this heated air passes into the engine. During its passage the air heats the thermostat A. A vacuum piston B is fitted to the air choke valve to open the latter when the engine starts so as to prevent excessively rich mixture from entering the engine.

General Characteristics of British Carburettors.—The majority of British carburettors employ the submerged jet or throttle-controlled mixture method of regulating the mixture strength for the main fuel supply. In one or two cases the multiple jet type of carburettor is still used. The use of a separate pilot jet leading from between the float chamber and main jet passage to the mixing chamber near the closed throttle position is also very common; this pilot jet provides a sufficiently rich mixture for starting and slow running, but is cut out of action as the throttle is opened. Means are nearly always provided for: (*a*) Varying the *strength* of mixture supplied by the pilot jet, and (*b*) varying the *amount* of mixture supplied. In the former case the pilot air opening is readily controlled by means of a sleeve, tube or screw, and in the latter case all that is necessary is a throttle-lever screw stop, to adjust the closing position of the throttle so as to admit more or less mixture.

Modern carburettors are fitted with acceleration pump systems for supplying the extra fuel required to keep the mixture strength correct—or on the slightly "rich" side when the throttle is opened quickly—and the air flow is relatively low, at first.

Another feature of some carburettors is the "power jet", which gives a slightly richer mixture at full throttle opening, in order to obtain the maximum power output—for, as we have previously stated, the mixtures which are richer than those giving complete combustion of the fuel have the highest power output qualities.

Hand controlled main air chokes for starting from the cold are fitted to most carburettors, but in more recent examples chokes controlled by thermostats,

* Automobile Engineer, April, 1938.

operating from the exhaust heat supply or conducted heat, are employed.

The down draught carburettor has latterly largely superseded the earlier vertical types, although the horizontal models are still used on certain models.

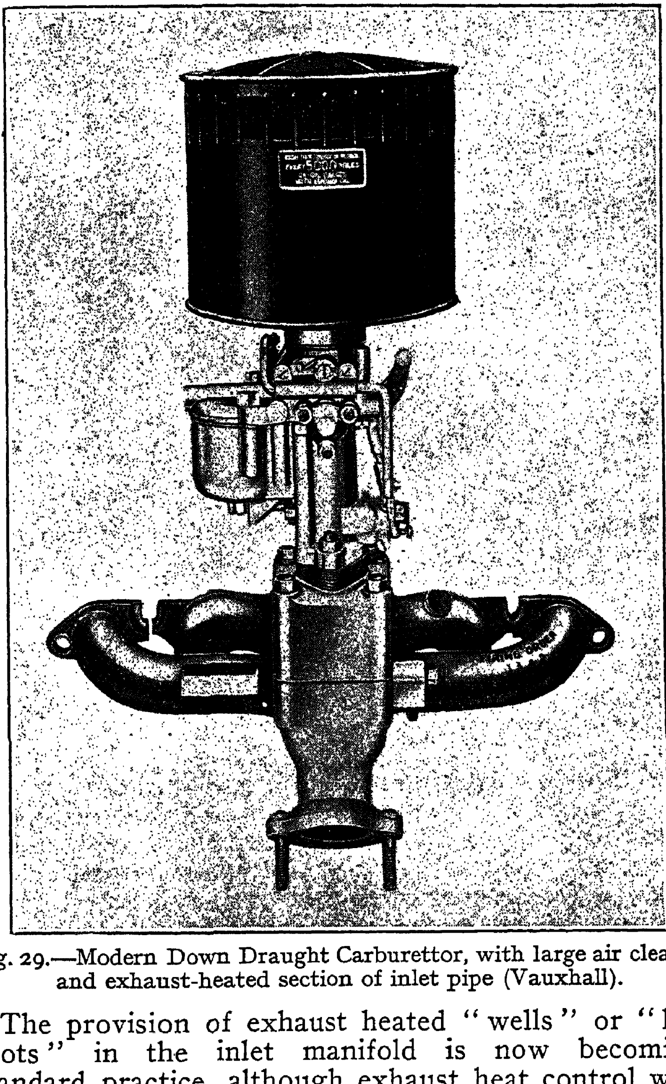


Fig. 29.—Modern Down Draught Carburettor, with large air cleaner and exhaust-heated section of inlet pipe (Vauxhall).

The provision of exhaust heated "wells" or "hot spots" in the inlet manifold is now becoming standard practice, although exhaust heat control with

throttle opening is not yet fully appreciated in British designs, but is a regular feature of American ones.

In general, however, the British design is less complicated and freer from interconnected controls than the latter type; it therefore does not suffer from objections to wear of the mechanism.

Some carburettors have a separate dashboard control for the mixture strength. In effect this controls the *absolute* value of the mixture (i.e., the ratio of air to fuel), whilst the automatic action of the carburettor maintains this absolute value approximately correct throughout the range of engine speeds and throttle openings. This control enables the mixture to be "set" to suit the atmospheric conditions, for example, in cold weather more fuel can be given (or less air), and in hot weather less fuel (or more air).

The separate extra-air valve is now seldom fitted; although this requires judicious use by the driver it can usually be arranged to give better fuel economy.

Air cleaners with combined silencing devices to suppress the carburettor "hiss" are now standard fittings.

Fuel filters of the fine wire gauze pattern are also incorporated in the carburettor design; usually, at the petrol pipe connection to the float chamber, in an accessible position for cleaning.

Float chambers are of the "offset" type, as distinct from the concentric American type. They are more bulky as a consequence, and must be carefully fitted to prevent "flooding" or "starving" the jet, on inclines.

The Zenith Carburettors.—The submerged jet, or well principle of compensation, illustrated diagrammatically in Fig. 12, is employed in these well-known instruments. Instead, however, of employing two side-by-side jets a compound jet is used, consisting of an inner main jet (as in the simple carburettor) and a concentric outer, or annular compensating jet supplied with fuel from a well, open to the atmosphere. A section of this compound jet is given in Fig. 30, whilst the vertical section through the vertical type carburettor is shown in Fig. 33, with the principal items annotated. As we have

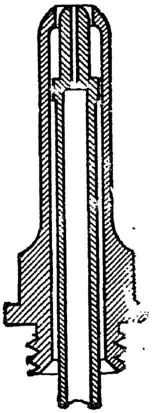


Fig. 30.—Section through Zenith Compound Jet.

explained previously, the increasing richness of the central main jet supplied mixture, as the engine speed increases, is compensated by the progressive impoverishment of the compensating jet mixture, the net result being one of constancy of mixture strength. The level of the fuel actually sinks in the outer concentric jet as the engine speed increases due to the fact that the compensating jet orifice or restriction shown is insufficient to maintain a sufficient supply of fuel to this jet.

The starting and slow running pilot jet shown in Fig. 33 is fed from the same well as the compensating jet, and consists of a very fine jet A (Fig. 31) which directs its fuel supply (the level of which is shown at *mn*) through the small tube G and thence via a by-pass into the side of the mixing chamber opposite the closed throttle position. Air to mix with this fuel flows in through the orifices *o* and *b*. It is possible to vary the strength of the mixture of this pilot jet device by screwing the head B in or out of the blackened portion shown, thus altering the relative positions of the jet A and the tube G; there is a spring catch for locking the two screwed parts referred to in any desired position. Further, the complete pilot jet unit can be removed from the rest of the carburettor, by unscrewing the screw shown on the right near B, for cleaning or adjusting purposes.

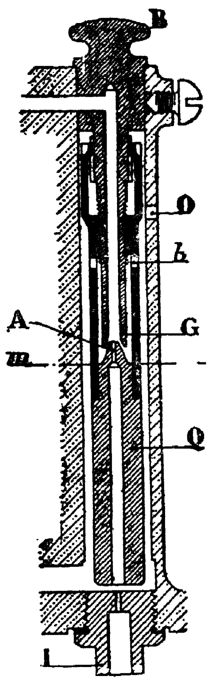


Fig. 31.—Section through slow running jet of Zenith Carburettor.

Referring to the complete carburettor (Fig. 33), it will be seen that any sediment or dirt entering with the petrol tends to collect in the hollows of the two

removable plugs shown beneath the main jet and compensating or "restriction" orifice. The usual float mechanism is fitted. The closed position of the throttle has an adjustable stop for regulating the slow running speed; this device enables the quantity of mixture past the throttle to be varied, whereas the pilot jet adjustment affects the quality or richness of the mixture. This type of carburettor was very popular for a number of years, on account of its easy starting, slow running and economy; it was simple to adjust and once set seldom required attention.

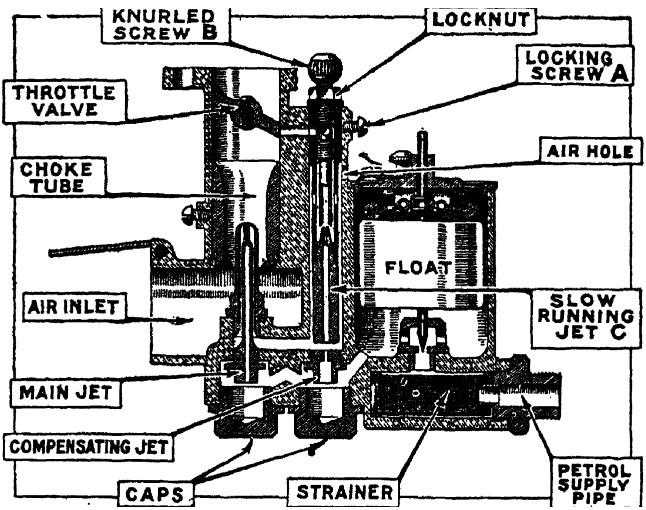


Fig. 32.—The Austin Seven Carburettor.

Austin Seven Zenith Carburettor.—Fig. 32 illustrates the type 22 FZ Austin Seven pattern Zenith carburettor used on certain models; the later ones use the Zenith "V" type. This follows the well-known principles in providing a main and pilot jet, with a well-compensator jet of the type previously described.

In the adjustment of this carburettor, it is necessary to ascertain by trial the correct sizes of choke-tube, main jet and compensator. The carburettor is, however, tuned to give the best results at the works, by the manufacturers. The standard setting is as follows: Choke, 15mm.; Main Jet ·70 mm.; Compensating Jet, ·75 mm.

In adjusting this carburettor to suit different conditions of altitude or temperature, the petrol should first be turned off, and the jets removed by means of a special key supplied. It is necessary to remove the caps beneath the jets beforehand. The slow-running device is regulated by turning the knurled screw B (Fig. 32), after having released the lock-nut shown.

The Zenith Triple Diffuser Carburettor.—This improved type was produced primarily in connection with the less volatile heavier petrols and fuels which

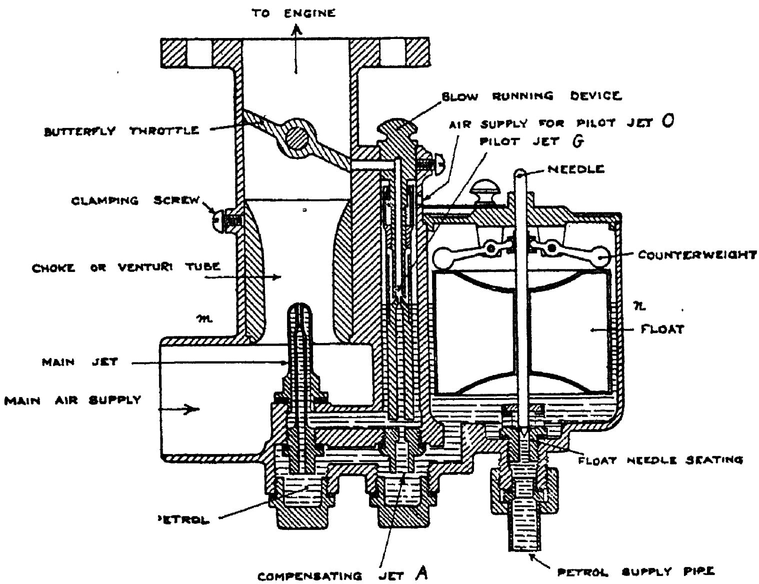


Fig. 33.—The Zenith Carburettor in section.

have replaced the lighter more volatile spirits of the earlier days. Its use enabled much better vaporization and atomizing to be effected. The same submerged jet principle as in the previously described type is employed, but in addition there is a high velocity air blast arranged in proximity to the fuel outlets from the jets, for pulverizing the fuel more thoroughly. Referring to the purely diagrammatic illustration of Fig. 34, A represents the main jet, to the immediate left of which is seen the compensating jet, and the restricted orifice B supplying the well G represents the

pilot jet passage leading to the carburettor near the closed position of the throttle. There are three diffusers, or choke-tubes, arranged around the fuel outlet, namely a very small one C, a second one slightly larger D, and a main choke-tube E, which is large enough to pass an adequate amount of mixture to fully charge the cylinders. The fuel leaves the

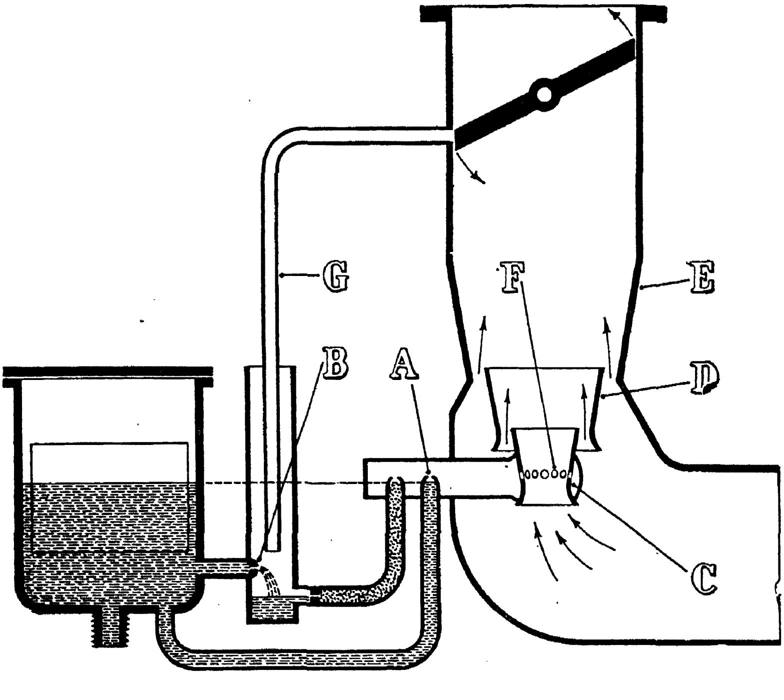


Fig. 34.—Illustrating the principle of the Zenith Triple Diffuser Carburettor.

main and compensating supply tubes through the holes F in the inner diffuser or choke C, where the great suction set up results in a very high velocity air stream which efficiently atomizes the fuel issuing from the holes F. This saturated mixture is mixed with air at a lesser velocity flowing through the diffuser D, and with a still slower stream through E. The different velocities of these three streams produces much turbulence and results in excellent atomization.

The carburettor is also provided with a mixture control lever connected to a small indicator on the dashboard, showing three positions; "Starting" for a temporarily rich mixture; "Normal" for ordinary running; "Weak" for level or downhill running, and in hot weather. These controls regulate the amount of air admitted to the starting and slow running tube, or pilot jet G. (Fig 34).

The Zenith U-Type Carburettor.—This carburettor had several advantages over earlier models. In the first place it was possible to remove the whole lower half of the carburettor containing the float chamber

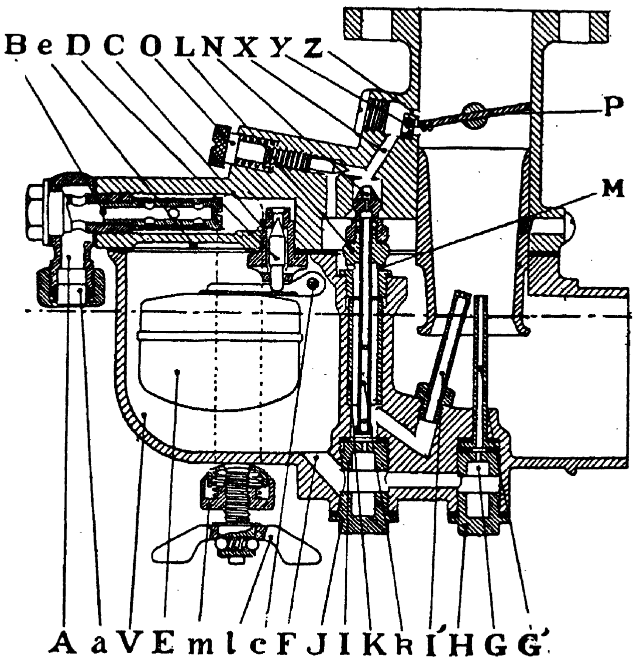


Fig. 35.—Showing principle of the Zenith U-Type Carburettor.

and jets, merely by unscrewing a four-winged locking nut on a hinged stirrup and swinging the latter upwards. This carburettor also possessed excellent acceleration properties, was economical in petrol and gave easy cold starting.

Further, no special tools were required to dismantle the lower half of the carburettor or the jets. Once having detached the lower half of the carburettor, the main jet, atomising compensating jet, slow-running jet and choke tube can readily be examined, adjusted or removed.

The principle of this carburettor is shown in Fig. 35. Petrol comes into the carburettor through the adjustable union A carrying the petrol pipe. It then passes through a gauge filter mounted in the end of the fixing plug B and so reaches the needle seating C, where it enters the float chamber V, and is regulated

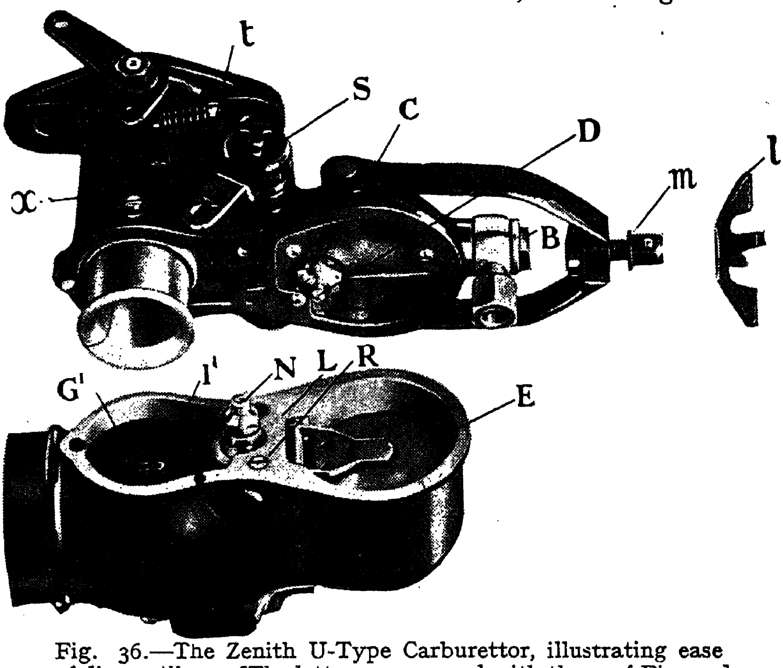


Fig. 36.—The Zenith U-Type Carburettor, illustrating ease of dismantling. [The letters correspond with those of Fig. 35.]

by means of the float needle D which is controlled by the float E, working on a horizontal pivot pin *c*.

This arrangement of the hinged float avoids any side thrust on the float needle. The top portion of the float chamber is maintained at atmospheric pressure by means of the hole *e*. Petrol then passes from the float chamber by means of the passage F to the main and compensating jets.

After leaving the passage F petrol will pass through the main jet G and then rise into the tube G^1 to the correct level.

The same thing happens to the compensator, but in this case the petrol rises in the well above it; also in the cap jet I^1. The main and compensating jets can be removed after the plugs H and J have been taken off. In the compensating well is situated the capacity tube K.

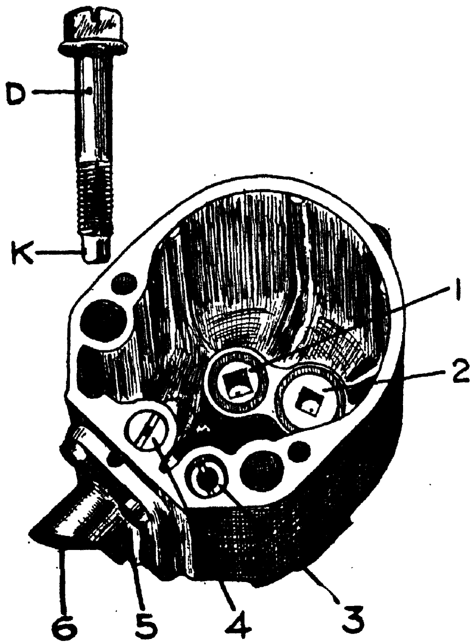


Fig. 37. Jet chamber of Zenith V-type carburettor. D is one of the two fixing bolts, having locating guide at K.

This tube is removable, and it is possible to vary the *acceleration* of any engine merely by changing the size of this tube.

For *slow running and starting* (Fig. 35) the top of the compensating well is closed by the plug L which is pierced with two holes, M, called ventilation holes. These holes allow the air to pass that is necessary to enable the compensator to work at atmospheric

pressure and also form an emulsion with the petrol issuing from the compensator, which of course finally passes through the cap jet I^1.

This plug L is called the " slow-running jet carrier " because attached to it is the slow-running tube *k*, and also the slow-running jet N.

The tube dips down into the compensating well and discharges petrol into the slow-running jet N, which is made in various sizes.

The petrol after having passed through the slow-running jet N enters the slow-running passage X, in which is also situated the screw for the adjustment of the air.

The screw O enables one to vary the suction on the slow-running jet and thereby regulate the strength of the mixture for slow running. The slow-running passage then opens out into the body of the carburettor just above the edge of the throttle P, when this is completely closed, by means of the passage Z.

Petrol from the slow-running jet can also pass through the lower passage Y as soon as the throttle commences to open. This gives a very progressive action.

The small screw Y is known as the progression jet, and as a rule has not to be changed.

For *easy starting* a rich starting jet R is fitted. This jet is fed directly from the float chamber, and is connected through the starting valve S to the upper side of the slow-running jet N. Thus when the lever *t* on the starting jet is pulled over it connects the passage X directly to the starting jet R. As the throttle is practically shut when starting a very strong suction is set up on the other side of the throttle valve; this draws petrol from the starting jet R and also from the slow-running jet N, so that a rich mixture is obtained. Once the engine has started then the valve S can be closed, thus cutting out the starting jet R, and the engine will continue to run on the slow-running jet N.

The Zenith V-Type Carburettor.—This more recent model, which has superseded the earlier "U" and

"H" types, embodies an automatic starting device, an original atomization and distribution method, and in some models an economy device and acceleration pump. It is supplied in the vertical, horizontal and down-draught patterns, which employ the same basic principles of operation.

The jet chamber of one model of this carburettor is shown in Fig. 37, whilst a sectional view is given in Fig. 38.

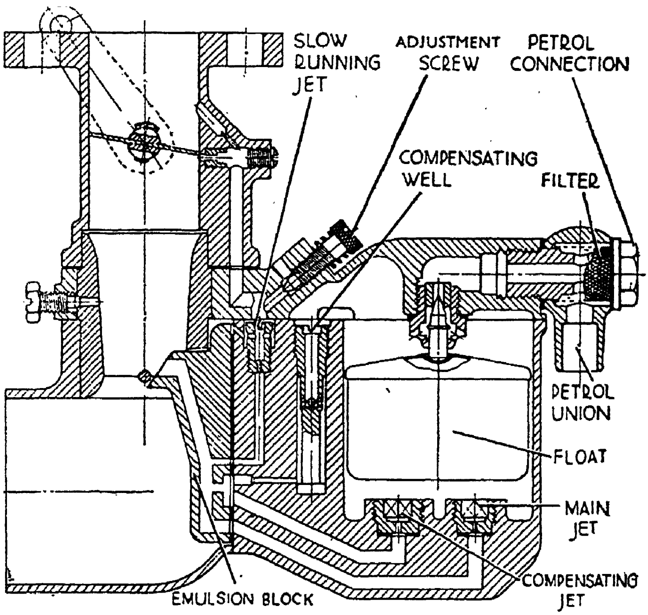


Fig. 38.—Sectional view of Zenith V-type Carburettor.

The petrol enters from the top side of the float chamber, the needle valve being above and integral with the float.

The float or jet chamber contains the main jet (1), compensating jet (2), compensating well (3), slow-running jet (4), (Fig. 37); to carburettors having the automatic starting device, a starter jet is fitted in addition.

The petrol flows through the main and compensating jets, and it also rises in the compensating well (Fig. 38).

From the jets the petrol flows along to separate channels into a common channel in the emulsion block (5), which is attached to the float chamber.

The petrol in the compensating well is in direct communication with the air and with the emulsion block, consequently all the petrol from the jets and well is now centred in one channel in the emulsion block.

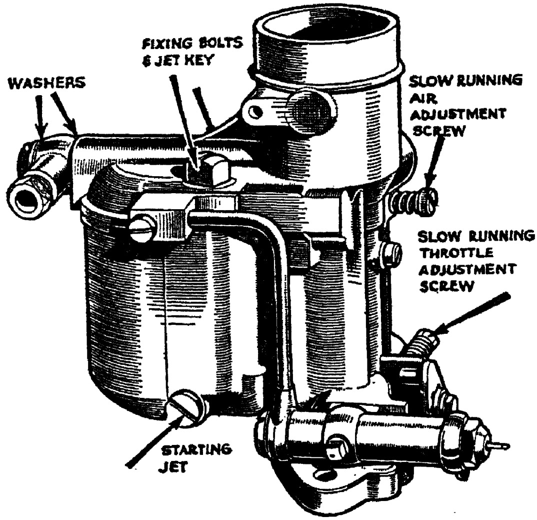


Fig. 39.—External view of Zenith V-type Carburettor.

This channel leads to a nozzle (6) that projects directly into the choke tube.

A special jet (4) is provided for slow running, and the petrol is drawn through this slow-running jet into a channel which leads to the engine side of the throttle. The petrol is atomised immediately on leaving the jet by air entering the carburettor at the base of the adjusting screw (Fig. 38).

The Zenith Downdraught Carburettor.—The more recent model 36 VEI is a V-type carburettor having a fully automatic strangler flap, which is interconnected with the throttle and used for starting purposes. In addition this model incorporates an important feature whereby the engine is arranged to run upon an economical air-fuel mixture at low to cruising speeds

but *a slightly rich full-power mixture* is supplied during the latter part of the throttle opening to the fully-open position.

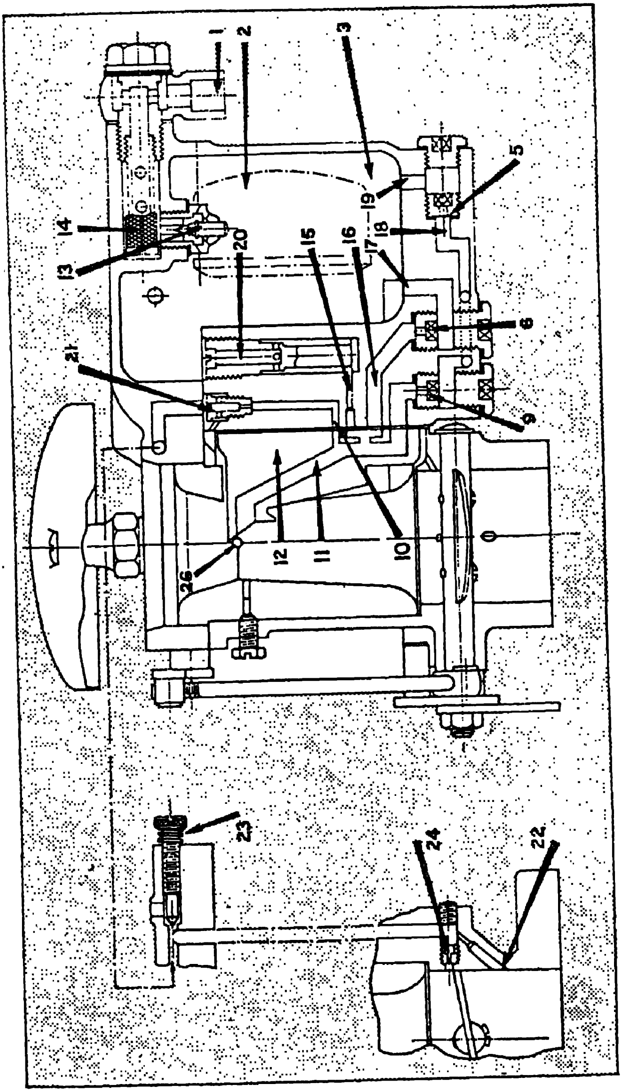


Fig. 40.—The Zenith Model 36 VEI, V-type Carburettor.

Referring to Fig. 40. Petrol enters the carburettor

at the union 1 and passing through a gauze filter 14 reaches the needle and seating 13. Unless the float 2 is already lifted against the needle by petrol in the float chamber 3 the petrol will continue its course past the needle into the float chamber. It will continue to flow until the various passages are filled and the petrol reaches a pre-determined level which causes the float to lift against the needle, pushing it on to its seating.

Petrol will have entered the passage 18 in the base of the bowl by passing through the outlet 19 and economy

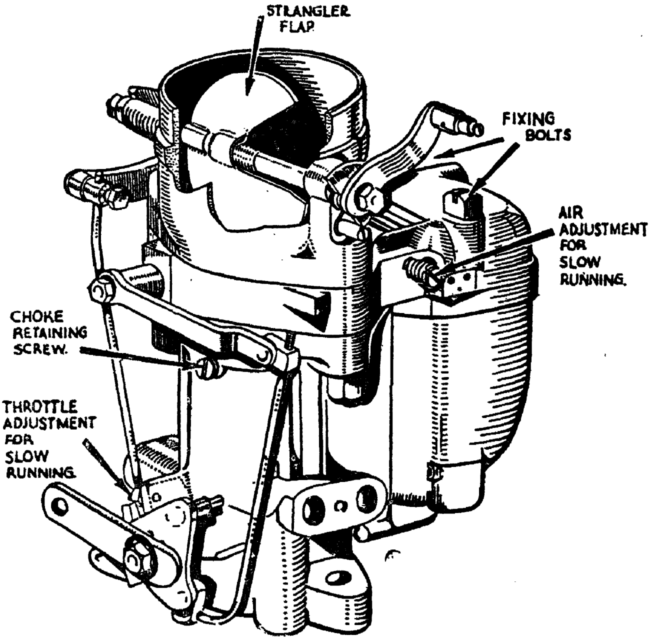


Fig. 41.—External View of Zenith 36 VEI Carburettor.

jet 5. It will then have passed through the main jet 9 into the main channel 11 in the emulsion block 12. Here it will remain at the pre-determined height, which is just below the emulsion block outlet.

The petrol will have also passed through 17 to the compensating jet 6. From the compensating jet the fuel passes along the passage 16 above it and joins the petrol from the main jet in the common channel 11. From the main channel in the emulsion block petrol

will pass into the slow running jet drilling *via* the passage 10. Similarly the well of the capacity tube 20 will be filled to the petrol level by the fuel flowing from the emulsion block through passage 15.

When the engine is started from the cold the strangler control on the dashboard is extended, which will result in the strangler flap closing the air-intake of the carburettor. A cam on the end of the strangler spindle will cause the connecting link to lift and open the throttle slightly when the strangler is closed. This will ensure sufficient volume and richness being obtained to give instant starting when the engine is turned over with ignition switched on. A rich mixture is necessary only to obtain the initial firing. Weaker mixture and greater volume is now necessary. The strangler flap is free to move on the spindle and is only held closed by the spring shown in Fig. 41.

After the starting the engine speed increases causing additional suction on the engine side of the strangler flap, causing the latter to open and thus to admit more air. Thus, the strangler automatically provides the normal mixture for warming-up purposes. It is usually advisable to return the strangler control to the inoperative position when the engine has become sufficiently warm and the main carburettor comes into action. With the throttle closed down to the idling position the mixture comes from the pilot jet 21 (Fig. 40). With the strangler out of action and the throttle just open the depression will be concentrated on the outlet 22 which will in turn be directed on to the slow running jet 10. Thus, petrol will be drawn from the well below the jet measured on passing through, and meet air entering at the base of the adjustment screw 23. The amount of air mixing with the petrol from the slow running jet is controlled by this air adjustment screw 23.

At the throttle edge there is a further outlet 24 which breaks into the slow running passage. Upon the throttle being opened from the idling position this will give an additional mixture to ensure progressive getaway from slow running—this explains the title of "progression jet" for that part situated at 24.

With the throttle opened still further the depression will be concentrated on the nozzle of the emulsion block which projects into the narrowest part of the choke tube. This will first result in petrol being drawn from the passage 11, 15 and 16, so that the source of petrol supply is eventually through the main and compensating jets 9 and 6. It will be observed that the petrol in the well of the capacity tube 20 has been consumed, and as the top of the well is open to the atmosphere petrol issuing from the main and compensating jets is now under atmospheric pressure. As a result petrol

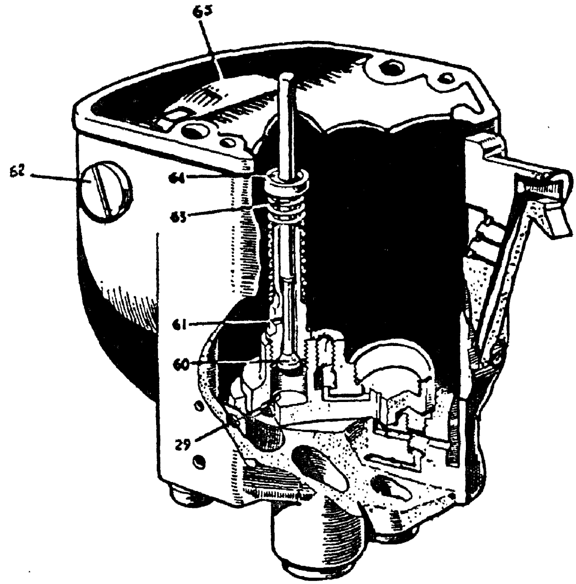


Fig. 42.—Zenith Fuel Economy and Full Power Device.

drawn from the jets will be broken up in the main channel 11 by air from the capacity tube. This mixture will then be drawn from the emulsion block nozzle into the choke tube.

It is essential that this mixture should be distributed completely across the choke tube in all directions. To obtain this even distribution a small circular bar, 26, has been placed across the choke tube at right angles to the emulsion block nozzle. Horizontal to the nozzle

another bar is placed. Actually this second bar is an extension of the screw securing the choke tube.

Air rushing from the intake will strike these two bars and create a vacuum on the sides facing the engine. The petrol-air mixture leaving the emulsion block will run along the bars, filling up the vacuum and then proceed past the throttle valve into the induction pipe.

It will be realised that as soon as petrol in the float chamber falls below the predetermined level the float will fall, permitting the needle 13 to drop, and petrol will pass into the chamber through the seating.

Fuel Economy and Full Power Device.—It was previously pointed out that a restriction in the form of an economy jet is placed on the main jet. The full effect of the main is only required during the last part of the throttle movement. Consequently the main jet is restricted until the economy device is brought into action. By means of an interconnection with the throttle lever, an arm connects with the top of the pump piston and depresses it during the last part of the throttle movement. This forces the valve, 60, off its seating and petrol will enter immediately from the float chamber at 61, flow past the valve 60 (Fig. 42) through the opening 29 and so into the main jet channel 18 (Fig. 42); thus the economy jet is by-passed and the full effect of the main jet is obtained as petrol is now flowing direct to this part.

As soon as the throttle commences to close the piston will rise against the action of the spring 63 and the valve 60 will return to its seat. Consequently the supply of petrol to the main jet is once more regulated by passing first through the economy jet.

The Vauxhall Carburettor.—The Vauxhall engines employ a modified type of Zenith carburettor, an external view of which is given in Fig. 43.

It belongs to the downdraught type and is designed to give economical mixtures for normal running and cruising purposes, but when the throttle is fully opened the mixture is enriched so as to give full power results;

it is thus possible to obtain greater mileages per gallon of petrol than with normal types of carburettor.

The operation is as follows:—The air enters the inlet pipe by way of the choke tube as usual. Projecting into the central part of this tube is an orifice formed

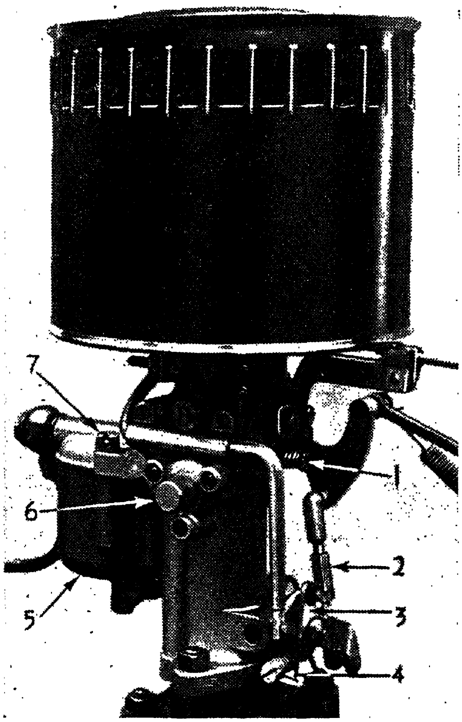


Fig. 43.—The Vauxhall Carburettor.

1, Idling mixture control screw. 2, Throttle connecting rod. 3, Acceleration pump stroke adjustment hole. 4, Slow running stop adjustment screw. 5, Carburettor float bowl. 6, Economy device housing. 7, One of the two carburettor float bowl retaining bolts.

at the end of the part termed the emulsion block. Petrol from the float chamber is admitted to a well (beneath the emulsion block) by way of main and compensating jets. At the same time a small quantity of air is drawn

into the block through a carefully proportioned hole called a "bleed." Little bubbles of air mingle with the petrol particles to form an emulsion which becomes thoroughly mixed with the main supply of air passing through the choke tube *en route* for the engine.

This part of the instrument is designed to give a full-strength mixture (the ratio is about 12 parts of air to one part of petrol, by weight), so that the engine is able to develop its maximum torque and power for acceleration, hill-climbing or running "all out."

During a considerable proportion of the running time on the road, however, an engine is operated with

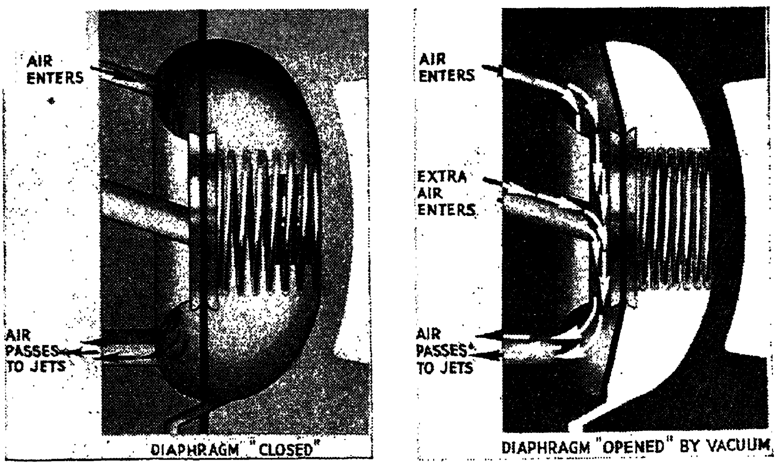


Fig. 44.—Vauxhall Carburettor Economy and Full Power Device.

the throttle partly closed, and it is then desirable that it should give the utmost economy. In order to make this possible an auxiliary air bleed is provided which is controlled by a spring-loaded valve. In the 25 h.p. engine a plunger is used, but in the 10 h.p., 12 h.p. and 14 h.p. engines, the valve is fitted to the centre of a diaphragm. The principle is the same in each case. The chamber at the back of the diaphragm is connected by a drilled passage to a hole in the carburettor throat just above the inlet pipe. Under part-throttle conditions the depression in the inlet pipe is enough to pull the valve back against the action of the spring, thus

opening the auxiliary air bleed (Fig. 44 right); the mixture strength is then reduced to about $17\frac{1}{2}$ to 1. On the other hand, when the throttle is full open, the depression in the inlet pipe is no longer sufficient to overcome the spring so that the inlet valve closes (Fig. 44 left), leaving only one air-bleed in action.

Another feature is the accelerator pump which comes into operation when the throttle is suddenly opened by a quick movement of the accelerator pedal. This pump (Fig. 45) gives the necessary sudden addition to the

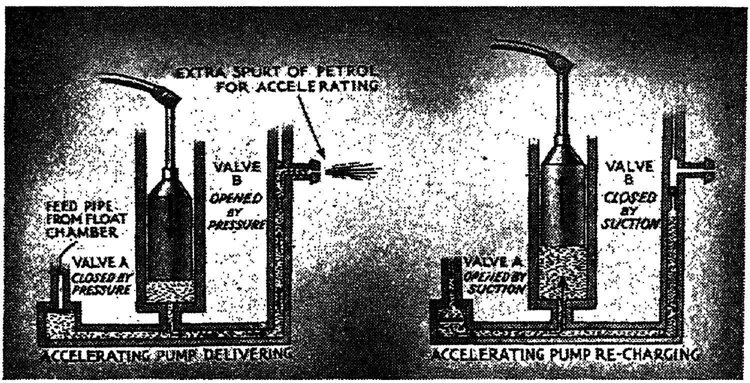


Fig. 45.—The Vauxhall Carburettor Acceleration Pump.

petrol to keep the mixture correct or on the rich side and thus to prevent a " flat spot " in the mixture range.

For idling purposes an independent slow-running jet comes into action. Another characteristic of this carburettor is the progression jet which comes into action when the throttle is beginning to open and keeps the engine going smoothly when the slow-running jet is no longer sufficient and when the main supply through the emulsion block has not yet commenced. A choke control is provided for starting purposes. This provides a rich mixture and, by an arrangement of levers opens the throttle slightly so as to increase the idling speed.

Starting Devices.—The V-type carburettor is made in several models having different starting devices; the latter include the usual air strangler method, but arranged to operate semi-automatically or fully-automatically, the air valve and the dip-tube methods.

When an air strangler is employed this takes the form of a butterfly valve inserted in the main air supply tube or inlet.

When the control from the dash is operated the flap closes the air intake, and upon the engine being turned over the depression is directed entirely upon the jets of the carburettor.

Consequently, a very rich mixture is supplied, and the engine starts readily and continues to run.

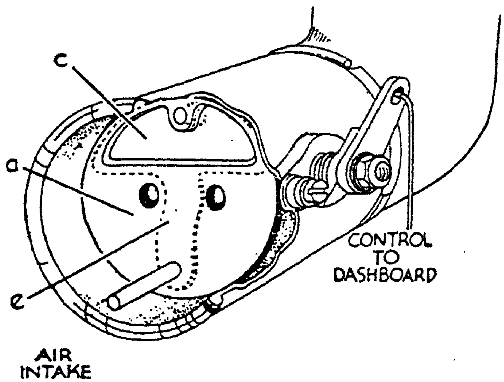


Fig. 46.—Semi-automatic Air Choke or Strangler.

It is often advantageous to give the engine one or two turns with the strangler closed and ignition "off". Then switch "on" and again turn the engine over by starter or handle.

Most stranglers are inter-connected with the throttle, so that the latter is automatically opened the correct amount when the strangler is closed. If this is not so, it is recommended that the throttle is opened slightly by the hand control.

Semi-automatic Strangler.—This type of strangler has the ordinary rigid flap (*a*), having in it an opening (*c*) covered by a diaphragm (*e*) as shown in Fig. 46. This will remain closed during the initial firing, but

as the engine speed increases, because of the general thinning of oil, easing of bearings, pistons, etc., the extra depression will cause the diaphragm to open.

Air is thus admitted, and the desired weakening effect obtained.

Fully-automatic Strangler.—As shown in Fig. 47, the strangler flap (*a*) is free to move on an offset spindle and is only held closed by the spring shown. When the extra depression is created, after the engine has started, the tension of the spring (*d*) is overcome and the flap opens to admit air to give the necessary weakening effect and provide varying volume. These

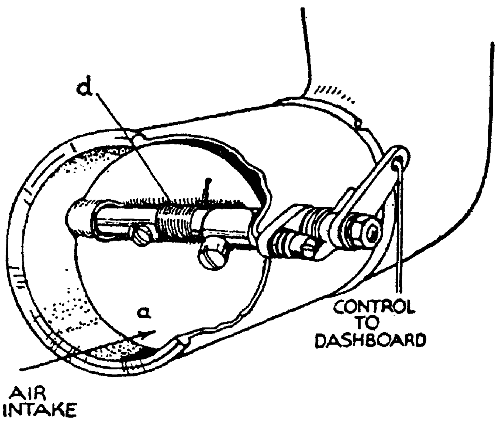


Fig. 47.—Fully-automatic Air Choke or Strangler.

stranglers give a buzzing noise which acts as a warning note that the strangler is in operation.

Automatic Starting Device (Dip Tube).—Some models of the V-type carburettor are fitted with a starting device similar to that shown in Fig. 48. Actually, this shows a down-draught carburettor, but exactly the same principles apply to other models.

To start the engine from cold the automatic starting-device control on the dashboard is operated, resulting in the main valve (26) being drawn off its seating to the position shown in the drawing. With the ignition switched on, the engine should now be turned over by means of the starter, ensuring at the

same time the throttle is not depressed. *It is essential that the throttle should not be opened beyond the normal idling position for starting purposes.* When the engine is rotated with the throttle in this position,

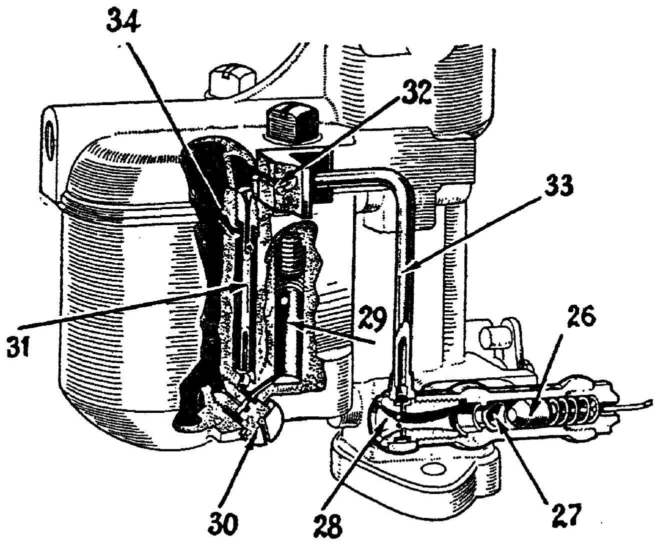


Fig. 48.—The " Dip Tube " Automatic Starting Device.

all the suction or depression created will be concentrated on the outlet (27) on the engine side of the throttle. This depression will be apparent at the venturi (28), and in the communication tube (33), which will result in air being drawn through the venturi, and petrol from the dip tube (31).

The petrol is drawn from the dip tube through the control jet at the top. It then passes across the connection (32), down the communication tube (33), to the throat of the venturi (28). There, the petrol is met by air entering the venturi and is broken up to form a rich starting mixture; the latter then passes into the induction pipe through the drilling (27). This rich mixture is required only for a short period.

Automatic weakening off is ensured by air from (34) mixing with petrol issuing from the starting jet (30) as soon as the fuel in the dip-tube well and reserve well (29) has been exhausted; the mixture thus becomes weakened.

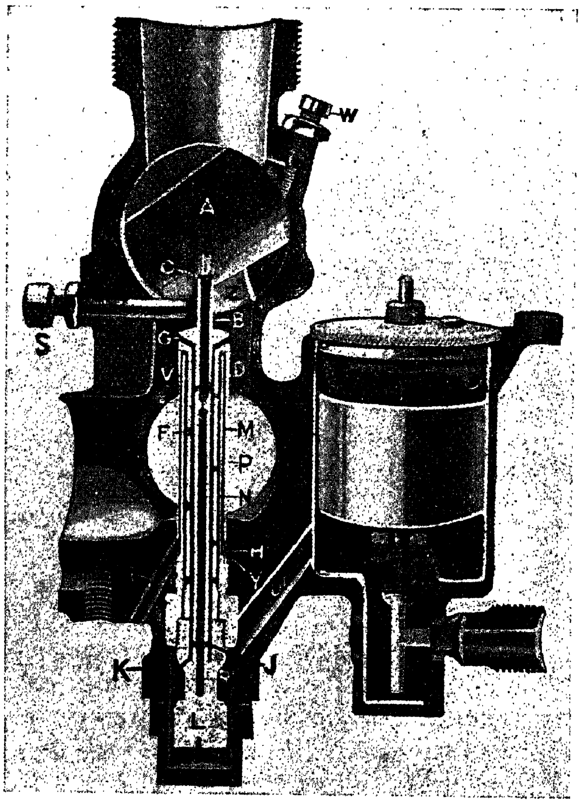


Fig. 49.—The Earlier "Z" type Claudel-Hobson Carburettor

The Claudel-Hobson Carburettors.—Two principal types of carburettor have been manufactured, namely the "air-injector" or "A" type, fitted with a single jet surrounded by a concentric air sleeve, and the "Z" type which is fitted with a diffuser jet for giving more

critical atomization, more particularly with the heavier grades of fuel now supplied.

In the " A " type, which will be described first, there is a single central jet, surrounded by a concentric air sleeve; the fuel in the jet stands almost level with the surface of the float chamber. The top of the jet projects into the mixing chamber, which itself is formed in the throttle barrel. The lower edge of the throttle is cut away, roughly resembling an elongated clover leaf, and forms the air regulator for the mixing chamber. The air tube surrounding the jet is perforated with air holes, one set of which is level with the top of the jet, and the other in communication with the carburettor air intake. When the throttle is shut, or

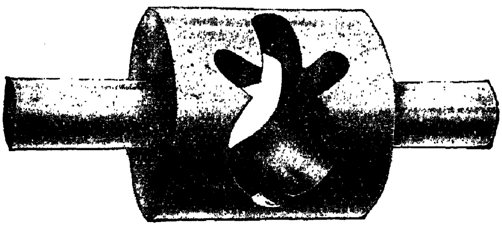


Fig 30.—The Throttle Barrel of the " A " type Claudel-Hobson Carburettor.

nearly so, the central slot fits round the top of the jet and its air tube, thus acting as an air regulator, maintaining a suction around the head of the jet at low engine speeds. As the throttle is opened and the engine speed rises, the suction increases and tends to draw out an excess of petrol, which tendency is corrected by the automatic action of the air tube round the jet, in conjunction with the special air ports cut in the throttle. The principle followed is an auto-mechanical one, and the action of this type will be clear from the illustrations. The carburettors in question are fitted with: (*a*) A by-pass passage, the

area of which can be varied by means of an adjustment screw, for controlling the quantity of mixture past the throttle when the latter is "closed"; this gives the slowest running adjustment. (*b*) A mixture

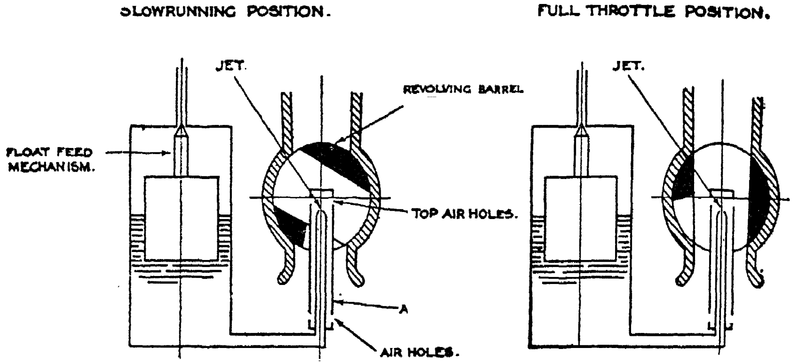


Fig. 51.—The "A" type Carburettor.

quality regulation screw, for varying the strength of the slow running mixture. (*c*) An air-flap over the main (and only) air intake, for starting-up pur-

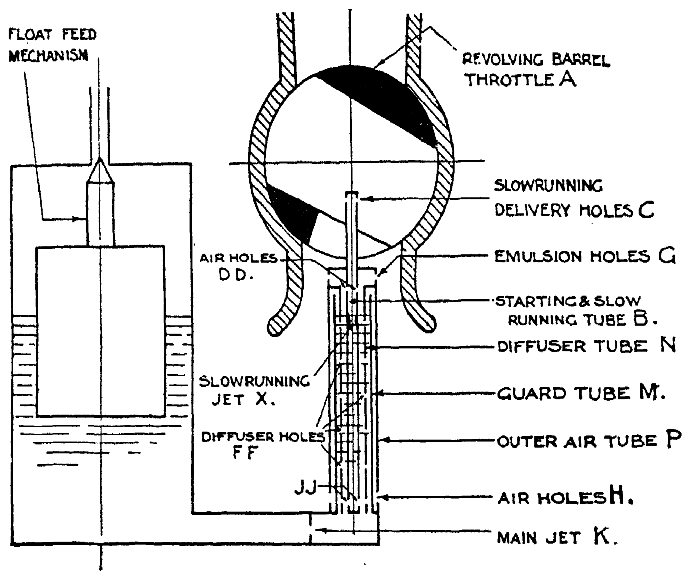


Fig. 52.—Diagrammatic Illustration to show Principle of "Z" Type Carburettor.

poses. (*d*) Petrol filters below the inlet to the float chamber and the jet; these can readily be detached for cleaning purposes.

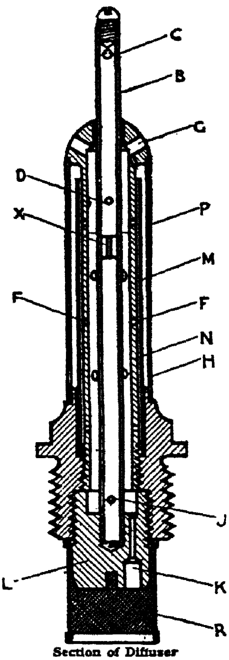


Fig. 53. — Section through jet of Claudel-Hobson Carburettor.

The "Z" type Claudel-Hobson carburettor embodies both the submerged jet and mechanical principles. The chief feature of this type is the construction of its jet, a sectional view of which is shown in Fig. 53, whilst Fig. 52, illustrates diagrammatically the principle. The main jet is of the submerged type, located at the base of the diffuser assembly. This consists simply of a calibrated hole K in the plug L. All petrol enters the diffuser through the main jet K, through which it flows into the three concentric tubes B, N and M. The outer tube P is an air tube only, and contains no petrol. The tube B is a starting and slow running tube. The holes JJ near its base admit petrol which has entered the diffuser through the main jet K. The delivery of petrol to the engine when idling by way of slow running jet delivery holes C is regulated by the restriction at X, which is the actual slow running jet. An air supply is drawn through the holes DD immediately above X.

Action of the Diffuser.—The provision of a correct mixture when the car is in motion falls upon the three concentric tubes, N. M. and P. (Fig. 52). Whilst the engine is running on the tube B and the slow running jet X, the main jet K admits more petrol than is required for slow running. Consequently a reserve of petrol is built up in the diffuser tube N and in the guard tube M, which communicate with each other via the diffuser holes FF.

The automatic action of the carburettor depends upon this reserve of petrol, as will be quite clear when the reader grasps two facts, viz.: (1) That the level of the petrol in the tubes N and M is continually

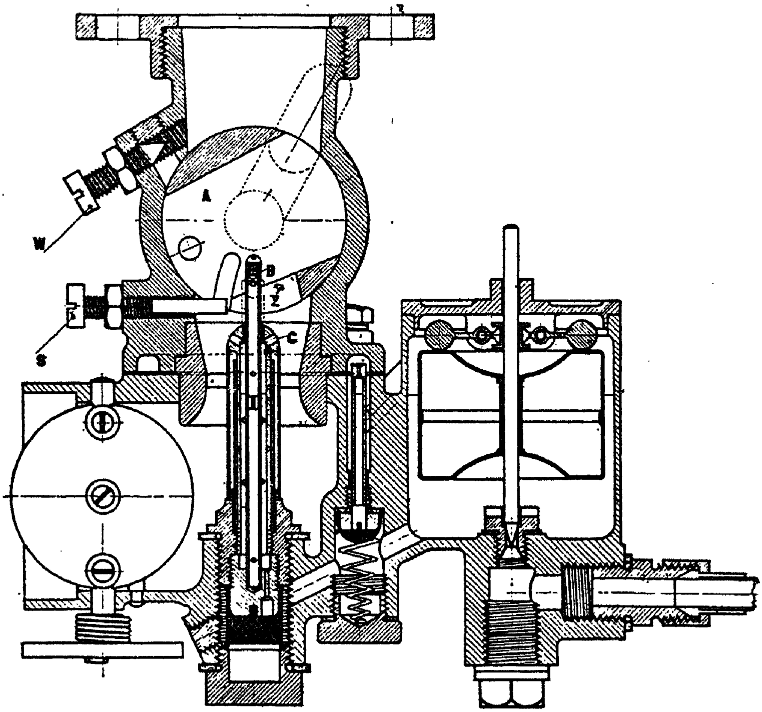


Fig. 54.—The "Z" type Claudel-Hobson Carburettor.

varying on the road in accordance with the engine speed and load. (2) That the variations in the petrol level in the diffuser affect the mixture.

Variations in Petrol Level.—When the engine is running on the slow running jet, the main jet K admits sufficient spirit to maintain a reserve of fuel in the tubes N and M at the level set by the float chamber mechanism. When the throttle is opened a little, the suction begins to take effect on the emulsion holes G, and as the petrol is drawn out of the tubes N and M, the level sinks. The more the throttle is opened, the lower the level becomes. The revolving barrel throttle A (Fig. 54), which is placed immediately

above the head of the diffuser, is provided with a slot Z on its under side, which admits of the slow running jet tube B being enclosed within the throttle body or mixing chambers, when in the closed positions. In the under part of the throttle are provided radial air slots or clover leaf cuttings, to regulate the delivery of the slow running jet at closed and intermediary throttle positions. An air screw S is provided, so that by screwing it in, the delivery of the slow running jet may be increased, and the resultant mixture enrichened. A by-pass screw W allows a fine adjustment on the quantity of mixture passing to the inlet pipe when the throttle is in the closed position. The head of the diffuser consists of a ring of holes G, drilled at an angle to the lines of flow of the main air supply. These emulsion holes deliver a rich mixture of highly atomized fuel and air, as proportioned by the automatic action of the diffuser, into the main air supply. In the closed position of the throttle, the slow running jet is providing all the fuel required for the correct mixture, but as the throttle is opened, the emulsion holes of the diffuser come progressively under the influence of the engine depression or "suction."

The arrangement described enables an approximately correct and homogeneous mixture to be obtained at all throttle positions and speeds, and the high degree of atomization obtained is a marked advantage in the case of heavier fuels and fuel mixtures.

The Power Jet Claudel-Hobson Model.—A special model Claudel-Hobson carburettor has been produced for high speed and maximum power conditions. In this case there is a supplementary jet which comes into operation only when full power is required.

It will be evident that this enables the most economical mixture strength to be used at all touring speeds except those corresponding to full throttle opening.

The object of the power jet is to provide the small amount of extra fuel required at full throttle to give the richer mixture corresponding to maximum power.

The characteristic Claudel-Hobson diffuser tube (Fig. 54) is retained in this new model.

The power jet is of the plain spray type, and is situated in the petrol delivery passage between the float chamber and the diffuser. The air supply to this jet is immediately over the jet orifice, and communicates with the passage leading to the mixing chamber via the throttle barrel, in the fully open position of the throttle.

When the throttle is fully opened the automatic action of the diffuser, combined with that of the power jet, gives the correct mixture, it is claimed, at all engine speeds. When the throttle is partly closed the power jet is cut out of action and the diffuser-jet then regulates the mixture strength.

A Butterfly Throttle Claudel-Hobson Carburettor.—In this model the usual cylindrical type throttle is replaced by a hollow butterfly throttle. A modified form of float chamber is used, and the power jet principle is also embodied (Fig. 55).

The slow running jet feeds the slow running mixture to a hole situated in the side of the carburettor body opposite the edge of the butterfly throttle. The feature of the slow running in this carburettor is the use of a passage situated in the throttle, which registers in the closed position with the slow running hole. It will be seen that the mixture is drawn not only past the edge of the throttle when the latter is a little way open, but is also drawn through the passage in the throttle, or as we style it, the "transverse hole." A portion of the mixture emerges from the throttle adjacent to the other side of the carburettor bore. There is a small hole in the centre of the throttle through which emerges a further portion of the slow running mixture. It will be seen that by this means, the mixture is not fed entirely to one side of the induction system, but more or less evenly throughout the whole area. Also, due to the fact that the depression increases on the transverse hole throughout the early part of the throttle movement, the flat spot—which is so prevalent on other types of butterfly carburettors—is obviated.

The adjustment of the slow running mixture is carried out by means of a change of jet and the

admission of a certain quantity of air, which is controlled by the adjustment screw C.

Referring to the main jet, the mixture is drawn through the emulsion passage in the body of the carburettor, into the tube which projects into the centre of the venturi or "choke tube."

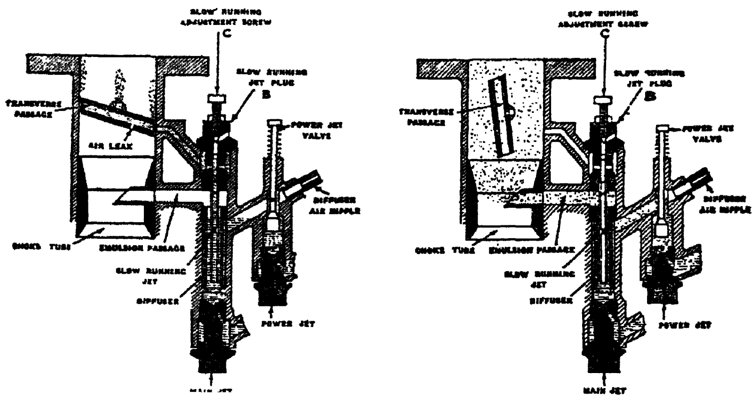


Fig. 55.—The Butterfly Throttle Model Claudel-Hobson Carburettor.

The control of the quality of the main mixture supplied is carried out by means of a change of the main jet. This latter adjustment can be made by simply removing the main jet, which is integral with the external plug, from the bottom of the carburettor no other dismantling of parts being necessary.

Control of the amount of air supplied to the diffuser is carried out by means of the diffuser air nipple. This can be varied in size to give a richer or weaker mixture at the larger throttle openings.

The power jet is situated at the bottom of the carburettor adjacent to the main jet. This supplies a small amount of petrol at full throttle only, as previously explained.

Claudel Atomiser Carburettor Development. — A more recent development of the Claudel carburettor is the model having a hot air supply to the mixing chamber to assist the vaporisation of the fuel.

The carburettor shown in Fig. 56 consists of three parts, viz., the float chamber, mixing chamber and throttle portion.

Petrol is fed into the lid of the float chamber through a gauze filter connection, and the fuel level is regulated by an inverted needle valve and a spherical float. There are three jets at the side of the float chamber, each in its own small chamber; the central one is the main jet.

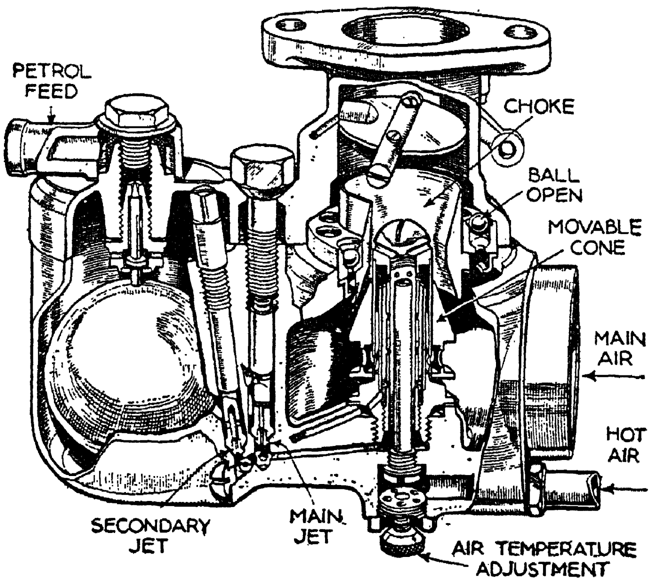


Fig. 56.—A Later Claudel-Hobson Development.

One of these jets is for slow running and for this purpose it has its own air supply, the latter being admitted to the top of the chamber through two small passages, one having an air regulating screw. The mixture from this chamber passes through a small by-pass to the throttle chamber, where it enters at the edge of the butterfly throttle; the latter has a hole in the edge which allows a little air to pass.

The main jet follows normal practice in supplying the main mixture except that it consists of four concentric tubes, the innermost one being plain, the next

one having certain small holes in it, the third one being plain, and the outer one having small holes in its lower part. This mixing chamber carries a head in which there are small holes. Hot air is led from a muff on the exhaust by a suitable pipe to the innermost tube, and an adjustable inlet for cold air allows an exact regulation of temperature to be obtained.

Petrol from the secondary jet is led to the outer annular space of the mixing chamber through another small passage, and between this and the corresponding passage of the main jet, feeding the inner annular space, is a fourth jet, the accelerator jet. Through this the main jet can augment its fuel supply for rapid acceleration, taking fuel from the secondary jet, this being made possible owing to the different depressions acting on the various portions of the mixing chamber. The main jet is subjected to a stronger depression than the secondary jet.

The head of the mixing chamber is located within a small choke tube, surrounding which is a ring of holes, each controlled by a small steel ball. The holes and balls are graduated so that the admission of air is automatically proportioned to the demands of the engine.

A cone surrounding the mixing chamber can be moved up or down to control the flow of air through the choke, to allow for easy starting. This also forms a means of adjustment when different grades of fuel are used.

Benzole, or Benzole Mixture Adjustments.—If the Claudel-Hobson carburettor is to be used with benzole, a suitable lead washer can be obtained from the makers, for weighting the float, in the "A" type, although this is not essential in the "Z" type. Generally speaking, the best results are obtained by fitting another jet, one size smaller, although if the carburettor has been used on petrol with the air screw well in, the necessary extra supply of air for benzole may be obtained by screwing it out.

Claudel-Hobson Down-Draught Carburettor.—The Claudel-Hobson carburettor used on some models of Armstrong-Siddeley cars is shown in Fig. 57.

The jets are readily accessible, the main jet with its plug being behind the throttle lever. Between the main jet and needle valve seat is the power jet, which is also formed integral with its plug. The slow-running jet, with its hexagon plug, is situated behind the strangler control mechanism. Situated on top of

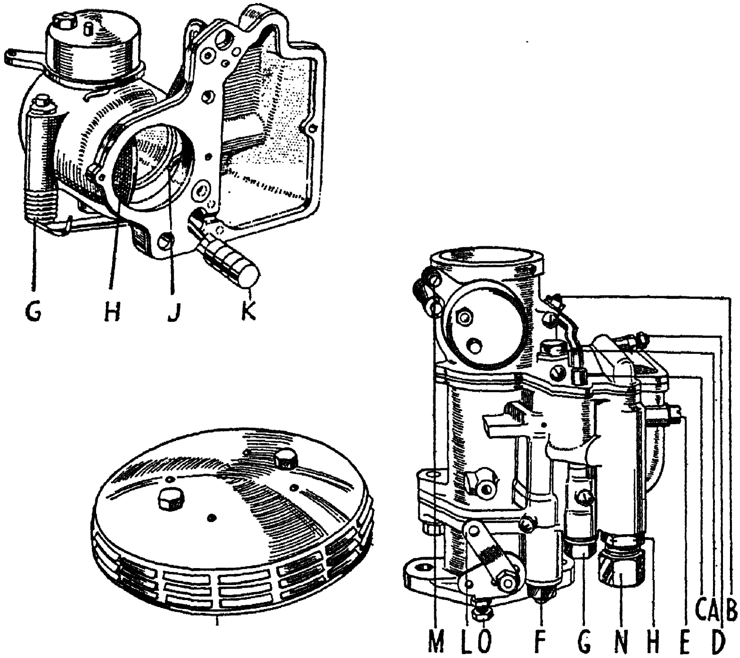


Fig. 57.—The Claudel-Hobson Down-Draught Carburettor.

A, The Slow Running Jet Plug. B, Pump Jet Screw. C, Power Jet Screw. D, Slow running Air Adjusting Screw. E, Float Lever Pin. F, Main Jet. G, Power Jet. H, Needle Valve Seat. K, Air Filter. L, Throttle Lever. M, Air Shutter. N, Petrol Pipe Union. O, Throttle Lever Adjusting Screw.

the float chamber lid is an adjusting screw, with lock nut to control the supply of air to the slow-running jet. The mixture is enriched by tightening the screw.

The carburettor is fitted with a strangler of the butterfly disc type for reducing the air supply for

starting purposes; it is controlled from the driver's seat.

The upper illustration in Fig. 57 shows the upper half of the carburettor; the pump-operating spring is indicated at G; the air strangler disc at H; the pump delivery tube at J; and the pump piston at K.

The Solex Carburettor.—This popular type is noted for its accessibility, comparative simplicity of design and also of operation. It works upon the submerged jet principle, and has in addition to the main jet, a separate pilot jet for starting and slow running.

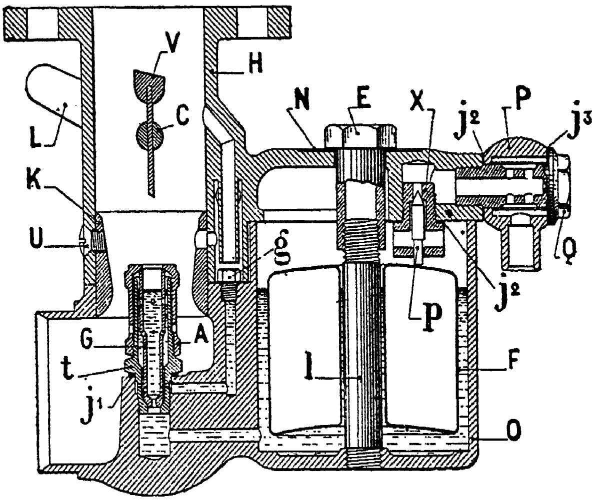


Fig. 58.—Sections of the Solex Carburettor, Type MOVT.

G, Main Jet. *g*, Auxiliary Jet. *t*, Main Jet Carrier. F, Float. A, Main Jet Cap. K, Choke Tube. P, Swivelling-filter Union. U, Choke Tube Fixing Screw. j^1, Main Jet Carrier Washer. j^2, Needle-valve and Petrol-union Washer. L, Throttle Lever. j^3, Large Swivelling-union Washer. *p*, Needle. V, Throttle. Q, Filter Union-assembling Nut. H, Body of the Carburettor. O, Float Chamber of the Carburettor. X, Needle-valve Seating. C, Throttle Spindle. E, Dismantling Nut. I, Central Pillar. N, Name-plate. W, Idling-adjusting Screw. *d*, Control Spring for W. Y, Idling-mixture Air Inlet. K, Choke Tube.

Referring to Fig. 58, which is a sectional view through the Type MOVT. model, the main jet is shown at G, and the pilot jet at *g*. The main jet, the principle of which is shown in detail in Fig. 59, consists of an inner jet G, with a restricted orifice at O, 25 mm. below the fuel level mn. and an outer cap A, containing two carefully calibrated air orifices S. This

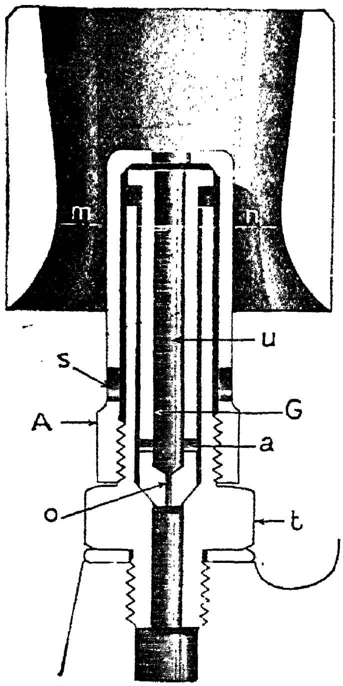


Fig. 59.—Showing Jet and Choke Tube of the Solex Carburettor.

arrangement ensures a rich mixture for starting and slow speeds and the correct mixture at high speeds due to the corrective effect of the progressively reduced supply of fuel, due in turn to the level of the fuel falling in the jet, owing to the inability of the small orifice O to supply sufficient fuel at the highest speeds to cause enrichment.

The pilot jet consists simply of a small calibrated, changeable jet *g* with its own air supply, and mixture passage to the interior of the cylindrical throttle, which when properly adjusted in the nearly closed position, by means of an adjustable screw stop, leaves a sufficient area for the pilot jet mixture to pass through to the engine. There is no means for varying the richness of the pilot jet mixture, other than by a change of jet *g*.

A commendable feature of this carburettor is its accessibility. By unscrewing the central nut on top of the float chamber, the float chamber and jet base, with the main air intake, can be at once removed, leaving the carburettor flange portion (containing the throttle, slow running stop, float chamber cover and petrol supply pipe and union) attached to the engine. The advantage of this arrangement is that for clearing the float chamber or changing either the pilot, or main jet, or choke-tube; it is not necessary to disconnect the throttle operating lever, break the petrol pipe joint or disturb the inlet pipe joint.

The power and acceleration adjustments are obtained by altering either the choke-tube or main jet; the starting and slow running variations, by

altering the pilot jet *g* (Fig. 58). The main jet can be removed by unscrewing the cap A (Fig. 59).

Solex Self-Starting Carburettors.—The original self-starting Solex Carburettors described in earlier editions of this book have since been replaced by the improved vertical, horizontal and downdraught models. The vertical (Types VB and VA) and horizontal (Types HF and AH) both incorporate the Solex " Bi-Starter " device, to be described.

Fig. 60 shows the horizontal model with the pilot jet *g* situated in the position common to all Solex carburettors.

The main jet *Gg* is the calibrated member, through which the petrol passes from the float chamber, and is screwed into the jet carrier *Y*.

In the vertical section of the channel leading upwards from the main jet will be seen the emulsion tube *S*, and screwed into the top thereof, the air correction jet *a*.

It will be noted that there is a number of holes towards the bottom end of the emulsion tube, and that there is an annular space between it and the surrounding casting, forming a reserve well *v*. This annular space is filled with petrol to float chamber level. As the throttle opens, air is drawn through the correction jet *a*. It passes down the emulsion tube *S*, through the holes, and emulsifies the contents of the reserve well *v*. The resultant emulsified mixture is drawn from the reserve well V, and passes to the engine in increasing volume directly in proportion with the degree of throttle opening, its final atomization being effected by the high velocity air current passing through the choke tube *K*.

The correction jet *a* is variable in tenths of a millimetre, and it is the selection of the size in relation to that of the main jet that determines the "correction" of the resultant mixture.

The Bi-Starter Device.—This is designed to give better starting and acceleration from the cold. The mixture obtained is richer as the temperature is lower,

so as to provide good cold starting results. Further means are provided for weakening off the mixture rapidly by pushing in a dashboard control knob about half-way, when the engine is warm enough. When the engine has reached its normal operating temperature the knob can be pushed right home.

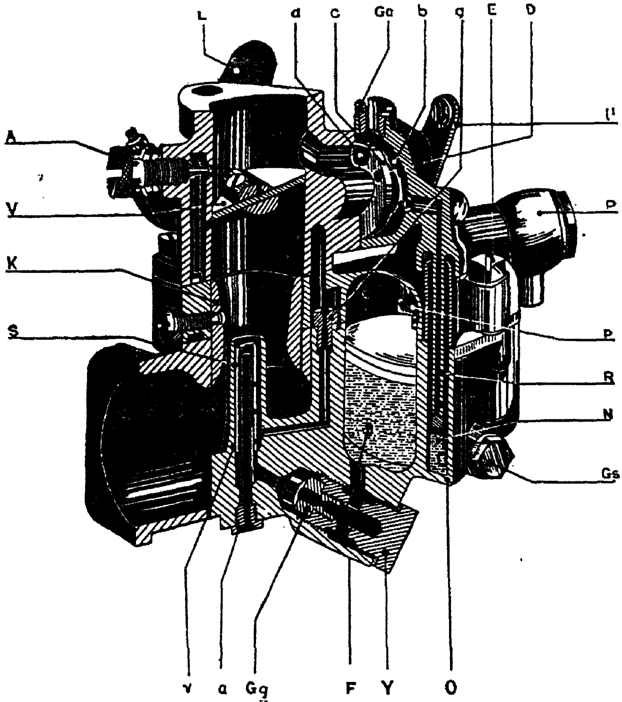


Fig. 60.—The Solex Bi-Starter Vertical Carburettor.

A—Volume control screw. V—Throttle. K—Choke tube. S—Emulsion tube. v—Reserve well. a—Air-correction jet. Gq—Main jet. F—Float. Y—Main jet carrier. o—Float chamber. Gs—Starter petrol jet. N—Starter well. R—Starter dip tube. p—Needle valve. P—Swivel union (petrol pipe). l¹—Starter lever. D—Disc valve hole (secondary). E—Dismantling bolt. g—Pilot jet. b—Starter mixing chamber. Ga—Starter air jet. c—Disc valve. d—Disc valve hole (primary). L—Throttle lever.

The action of the Bi-Starter can be followed from the part sectional view shown in Fig. 60.

On pulling the dashboard knob the lever moves to the position shown, and the valve-disc *c* rotates until

the hole *d* registers with the channel entering the throttle chamber immediately above the butterfly.

Turning the engine at once produces a suction on this channel, which lifts the petrol from the well *N* *via* the dip-tube *R* (Fig. 60) into the mixing chamber *b* immediately behind the valve-disc *c*.

Here it meets a high velocity air stream entering the mixing chamber *via* the air jet *Ga* (Fig. 60) so that an atomized mixture of petrol and air is drawn into the cylinders, when an immediate start is obtained.

The petrol jet *Gs* governs the supply of petrol to the well *N* by gravity flow the well being open to the atmosphere. Since there is a direct suction on the air supply *via* the air jet *Ga* only a constant quantity of petrol, as governed by the size of the petrol jet *Gs* can be drawn from the well *N*. After starting and running for a few seconds the engine speeds up to 4 or 5 times the normal idling speed on a decreasingly rich mixture, since more and more air is taken through *Ga* for a constant amount of petrol through *Gs*. The mixture can, however, be weakened still further to enable the engine to run regularly when well warmed up. Below the mixing chamber of the starting device is a ball-spring in contact with an internal cam connected with the lever l^1 (this is not shown in Fig 61). If l^1 is pushed back half-way the ball rises and resists the motion of the cam to show when the second position bringing the hole *D* in line with the entry channel is reached; in this position the volume of mixture is reduced.

The Solex Downdraught Self-Starting Carburettor.—This modern development of the Solex Carburettor represents a notable improvement upon the two-stage model having an idling and main jet. It embodies three stages to give better mixture control over a wider speed range with good starting qualities in all weather conditions.

It comprises (1) *An idling or pilot jet*, as before. (2) *A main jet* with wide mixture correction limits. (3) *A membrane pump* which can be regulated externally to any desired output in order to prevent any flat

spot on opening out with a weak mixture setting. (4) *A statically-operated speed jet* constituting the third stage and providing the required increase in the fuel output to enable maximum power and speed to be obtained as full throttle is approached, independently of smaller throttle economical mixture settings; and (5) A bi-starter device of the kind previously described.

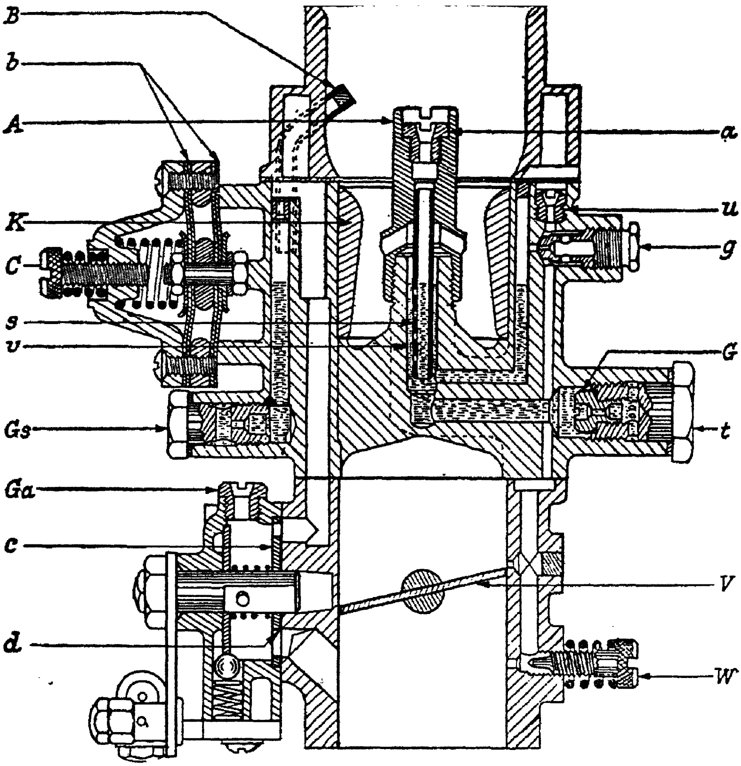


Fig. 61.—The Solex Self-Starting Down Draught Carburettor. Type 30.A.I.P.

A—Jet Cap. a—Correction Jet. B—Speed Jet. b—Pump Membranes. C—Pump adjustment screw. c—Starter Valve. d—Orifice of above. G—Main Jet. g—Pilot Jet. Ga—Starter Air Jet. Gs—Starter Petrol Jet. K—Choke Tube. s—Emulsion Tube. t—Main Jet Carrier. u—Air Bleed. V—Throttle. v—Reserve. W—Volume mixture control screw.

The carburettor is shown, in sectional view, in Fig. 61; for simplicity reasons the float chamber and

fuel ducts leading to the main and starter jets and pump have been omitted. The submerged main jet *G* is mounted in a carrier *t* and fed from a duct leading from the float chamber. The petrol from this passes to the left and upwards to the spraying assembly where it is corrected in the following manner:—First, it enters the reserve well which is a permanently cast-in base of fixed height and diameter; and externally threaded at the top for the reception of the jet cap *A*. This comprises three essential features. The Emulsion Tube *s* which is a "press-fit" therein and extends downwards to the bottom of the well. An air correction jet *a* which admits a metered quantity of emulsifying air, and, six downwardly sloped channels, of which two are shown laterally, to lead the resulting mixture into the waist of the choke tube *K* where it meets the main air stream at a constricted point of high velocity.

Functioning of the Main and Auxiliary Jets. When idling, the main jet is inoperative and the level stands high in the well as illustrated in Fig. 61.

From the bottom of this well, to the right and just above the large duct leading from the main jet *G* will be seen the smaller pilot jet feed duct emerging and turning sharply upwards to this member *g* which meters the fuel into the downwardly directed and still smaller channel to the right, capped by the air bleed jet *u*. It is eventually led *via* this to the final spraying orifice regulated by the spring-loaded screw *W*. As this orifice is in a position where the suction is very high, the engine when idling draws its petrol from the main jet reserve well which is then full. As soon, however, as the throttle is opened and the air speed rises in the choke *K*, the main assembly starts to function and the pilot simultaneously goes out of action through starvation. Petrol is drawn up the annular space between *s* and *v* while air is drawn in at *a*. The latter passes down the tube *s*, and out through the wide holes shown at the left where it meets and emulsifies the rising petrol in the annular space, upon which the frothy mixture passes out *via* the downwardly inclined channels into the choke waist where it is caught up and atomised by the high velocity main air stream. At low speeds the downward air current from *a* does not

materially interfere with the upward petrol movement in the annular space, but as the speed becomes high, interference gradually prevails and progressively obstructs the fuel, hence the so-called "correction" and the reason why a bigger main jet *G* only affects pick-up at low and medium speeds and a bigger or smaller air correction jet *a* is introduced, respectively, as required.

Membrane Pump. Reference to Fig. 61 will show this as a chamber divided in half by a double spring loaded diaphragm, the movement of which to the left is governed by the adjustment of the screw *C*. There are two chambers here. The left one of approximately conical shape, containing the large spring, communicates by a channel, not shown, with the self-starter outlet below the throttle and, therefore, in a position of high vacuum when idling; and the right one communicating with the petrol-filled space above the self-starter jet *Gs*.

When the throttle is shut, a heavy suction is communicated to the left chamber, pulling back the diaphragm *b* against the big spring as far as the screw *C* will allow and drawing into the right hand chamber, therefore, a proportionate quantity of petrol *via* its duct which is sealed by a non-return ball valve, not shown.

Whilst the throttle is closed the reservoir is full, but when suddenly opened for acceleration the vacuum in the left chamber is relieved and the diaphragm is then pushed by the compressed spring to the right, so that the contained petrol is ejected into the air stream *via* the jet *B* and thus helps the acceleration in a direct measure as the screw *C* is withdrawn so as to increase the diaphragm stroke. The jet *B* also operates further up the speed range as a *Static Speed Jet.* Thus, if the throttle is held wide open the pump ejection will soon cease, but simultaneously a depression starts to develop in the wide space around *B* and this lifts the petrol column just below the bottom of this jet (shown in dotted lines in Fig. 61); the jet then commences to operate from this again with an increasing output, owing to the rising suction effect; this increases the

mixture strength in the wide-open throttle positions. As the throttle is closed the additional suction around *B* ceases and the speed jet becomes inoperative.

Acceleration Pump.—The Solex acceleration pump, which is fitted to certain models is illustrated in Fig. 62. The pump shaft is connected to the throttle opening mechanism, and on the downward stroke the petrol previously drawn into the barrel through the inlet ball valve is expelled through the outlet valve into the pump jet. The more rapidly the throttle is opened the greater will be the pump effect.

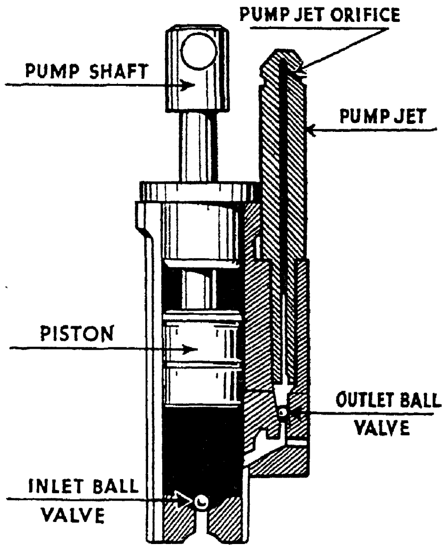


Fig. 62.—Acceleration Pump on Solex Carburettor.

The Solex Thermostarter Carburettor.—This recent type belongs to the class having a heat-controlled device for providing rich mixture for starting from the cold, from a separate small carburettor having its own petrol jet and air supply.

There are two different units in the starter carburettor system, namely, the starter carburettor and the thermostat for automatically connecting the starter carburettor outlet with the orifice above the butterfly throttle, i.e., direct with the engine.

The principle of the Solex thermostatic control is shown in Figs. 63 and 64.

The jet *Gs* feeds the starter well jets and provides a high-velocity air stream for atomising the petrol. This starting mixture passes into the carburettor *via* the inclined port shown on the right, just above the throttle. Distortion of the bi-metallic strip B at a set temperature bends it to close the aperture O, i.e., the end of the connecting pipe between the thermostat

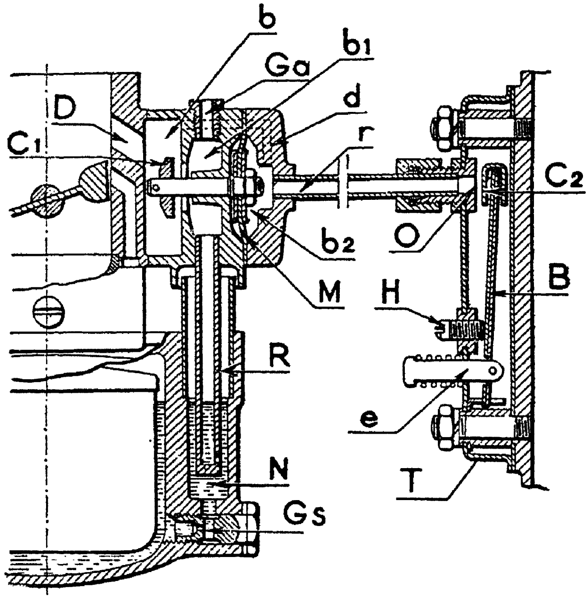


Fig. 63.—The Solex Thermostarter Carburettor.

A Section of the Solex Thermostarter showing the position of the Bi-metallic Strip B when the Engine is cold and the Orifice O therefore open.

q, Vacuum Chamber. b_1, Vacuum Chamber. b_2, Vacuum Chamber. B, Bi-metallic Strip. C_1, Starter Valve. C_2, Bi-metallic Strip Valve. D, Mixture Supply Port. *d*, Vacuum Balance Tube. *e*, Thermostat Spring Anchorage. *Ga* Air Jet. *Gs*. Petrol Jet. H, Bi-metallic Strip Fulcrum Screw. M. Membrane of Valve C. N, Starter Well. O, Control Orifice. R, Dip Tube. *r*, Starter and Thermostatic Union Pipe. T, Thermostatic Box.

and the starter unit. The latter unit is all ready to function when it is desired to start the engine. When the thermostat actuates the starter unit the latter is pushed out of action immediately.

The thermostatic box is fixed on the engine's exhaust pipe, and it contains a bi-metallic strip, one end of which is fixed and the other fitted with a valve C_2 (Fig. 64). The strip in question is spring-loaded so as to keep in contact with an adjustment screw H, which acts as a fulcrum. The valve C_2 is placed in front of an orifice at the end of the tube, and when open puts the starter in communication with the thermostat.

The bi-metallic strip is the actuating element of the thermostat: it is made up of two stainless metals, having different expansion coefficients, which are welded together along their whole length.

When this is heated it is bent by the action of the different expansions of the two metals.

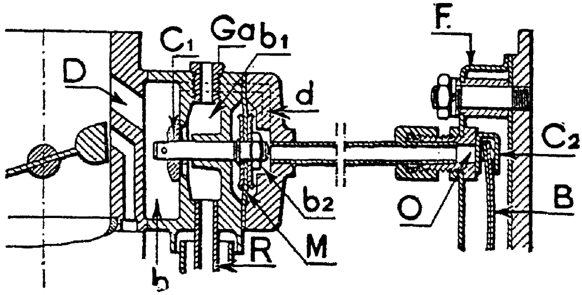


Fig. 64.—Position of the Bi-metallic Strip B when the Engine is hot; the Orifice O, it will be seen, is here closed by the Valve C_2.

When it is cold, and consequently straight, the valve C_2 is removed from the orifice O (Fig. 63), but on a certain predetermined temperature being reached, the distortion of the strip forces the valve C_2 into contact with the orifice O (Fig. 64), and puts the starter out of action.

The action of the starter is controlled by the movement of the valve C_1, which is operated *via* its stem by the membrane M. This membrane M is in effect the expanding wall of a chamber b_2 to which is transmitted the suction of the engine, through the tube *d*, and which is also connected to the thermostarter box by the union tube *r*. When the engine is started, either by hand or by the electric motor, the vacuum created in the chamber *b* *via* the tube D

causes the valve C_1 to open. The chamber b_1 is then subjected to the engine suction and the starter works normally.

At the same time, however, the chamber b_2 is similarly put into depression by the suction of the engine through the tube *d*; this action, however, is very weak owing to the excess leakage through the relief orifice O *via* which the air enters. As soon as the engine is warm, the orifice O is shut by the bi-metallic strip valve, the vacuum in chamber b_2 becomes equal to that in chamber *b*, and, as the surface of membrane M is greater than that of the valve C, the suction on the former is the stronger and the valve shuts.

In this way the starter is put out of action, and before it can operate again the temperature must have dropped sufficiently to allow the bi-metallic strip to straighten and uncover the orifice O. In other words the "starter" will remain inoperative until the engine cools down.

Whilst the engine is warm, it will start readily on the pilot jet of the main carburettor.

Adjustment of Carburettor.—Should it be desired to carry out any regulations to the starter air or petrol jets when the engine is hot, the thermostat can be put in action regardless of temperature by loosening one of the joints on the copper connecting tube which will admit air and prevent thermostatic cut-off.

It is inadvisable to tamper with the internal arrangements either of the thermostat or the starter.

If either should refuse to respond to the above adjustment or the temperature alterations as effected by the use, or otherwise, of "distance washers" between the thermostatic box and the exhaust manifold, it is best to return them to the makers for attention fully assembled.

The Solex Governor Carburettor.—This commercial vehicle model has a governor device for limiting the engine speed to a pre-determined value, above which

the engine will not operate. The carburettor resembles the standard model, but contains in addition a sealed governor device (Fig. 65).

The governor operates on the velocity principle, and has no mechanical connection with the rest of the engine.

The velocity of the ingoing air stream takes effect on the inclined face of the butterfly throttle so as to close the latter in order to maintain the engine speed constant.

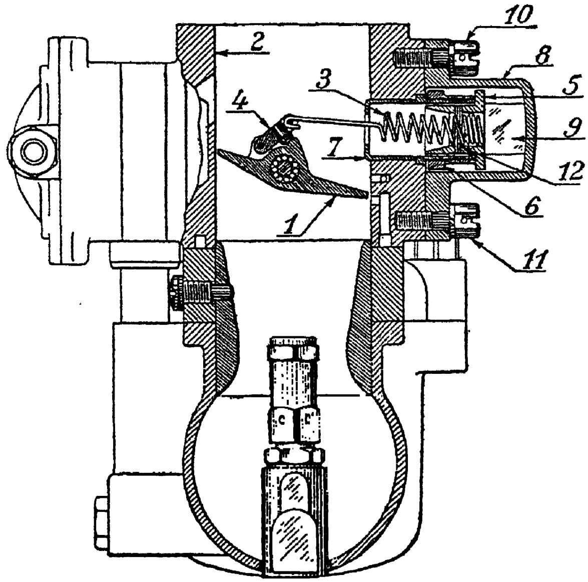


Fig. 65.—The Vertical Model Solex Governor Thermostarter Carburettor.

1, Butterfly. 2, Throttle Chamber. 3, Governor Spring. 4, Spring link Anchorage. 5, Spring-regulating Sleeve. 6, Tension Nut. 7, Threaded Guide for Tension Screw. 8, Locking Cover. 9, Cover Guide. 10-11, Fixing Screws. 12, Steel Peg.

Referring to Fig. 65, it will be seen that the throttle is mounted eccentrically on the spindle, i.e., the " tail ", or lower half, is longer than the " head ". Thus air pressure on the head has the closing effect mentioned.

Resisting the closing effect of the air charge is a coil spring (3), anchored to the throttle. Since the

pressure of the air charge on the throttle—or butterfly—or vane—(they are all the same thing)—increases as the engine speed rises, it will be clear that by adjusting the pull of the spring to any required tension, the throttle will start to close when the pressure of the air charge, and therefore the engine revolutions, reaches an equivalent value.

In order that the throttle shall be properly sensitive to the opposing forces of air pressure and spring tension, it floats on a hardened and ground spindle on needle roller-bearings. The spindle in turn operates in substantial bronze bearings with full provision for taking end thrust. It is coupled to the accelerator in the usual way, but the throttle is free to rotate on it independently. This free movement is limited by a simple drive, of dog formation, between spindle and throttle. The result is that the throttle is always positively closed by the dog when the accelerator pedal is released, but on pressing it down again the throttle is opened by spring (3) as the dog drive recedes from it. Sufficient lost motion is allowed for throttle movement on the spindle during governing, so that the driver's foot can always be kept right down on the pedal, and the governor, meantime, will operate freely, controlled only by the speed of the engine.

The outer anchorage of spring (3) consists of a steel peg (12) housed in a sleeve (5) and passing through the spring coils. The sleeve itself has no lateral fixing device, but the inner face of its hexagon abuts against the outer one of the tension nut (6), as shown in the cross-sectional view. This member is threaded, and screws on to the housing (7). By screwing (6) out or in, therefore, sleeve (5) will also move with it, and increase or decrease, as the case may be, the tension of the spring.

In order to avoid "hunting" or "surge" effects advantage is taken of the natural frequency of vibration of the governor spring. The frequency of this spring is adjustable so that it is possible to match up the spring rate to the pulsating action of the air charge on the throttle to suit the selected engine speed.

The sleeve (5), if revolved, will cause the peg (12) to be screwed along the spring, thus altering the number of coils between peg and spring hook. These, which are the ones in action, are the only ones that matter, those on the outer side, farthest from the throttle, being "dead".

The successful tuning of a Solex governor carburettor, therefore, centres in the adjustment of spring regulating sleeve (5), and tension nut (6).

The action of the governing device is, briefly, as follows:—

On depressing the accelerator pedal, the dog drive on the spindle allows the throttle to open fully under the influence of the spring.

The pressure of the air charge on the tail of the throttle is at first very light and does not move it. As the selected governed speed is approached, however, the throttle commences to close and the pressure builds up very rapidly indeed as this closing movement progresses.

A correspondingly sharp increase in the build-up of spring resistance is called for, without having to alter the already determined tension at the full open-throttle position, and this is provided by the link (4) and its boss, as already described.

In this way the throttle remains wide open until immediately before the governing speed is reached, so that pick-up is not restricted. Then the whole of the closure takes place over the smallest possible number of engine revolutions.

The S.U. Controllable Jet Carburettor.—This design of S.U. carburettor is fitted to several makes of British car, including the more recent Morris and Wolseley cars. The principal feature of this carburettor is the suction-operated piston which varies the size of the choke and, in addition, controls the delivery of petrol from the jet by means of a tapered needle.

There are two types of S.U. carburettor, namely, the horizontal and downdraught. The construction of these is similar, the only difference being that the suc-

tion piston of the former falls by its own weight, whereas that of the latter is depressed by means of a spring, as shown in Fig. 67; the horizontal carburettor only is fitted with a hydraulic suction piston damper. This is a device located in the hollow piston rod and attached to the oil cap nut. It consists of a plunger with a one-way valve, its purpose being to give a slightly richer mixture by preventing the piston from rising unduly quickly on acceleration. This device is fitted on a more recent model S.U. carburettor shown in Fig. 69.

The principal parts of the carburettor are shown, clearly in Fig. 66.

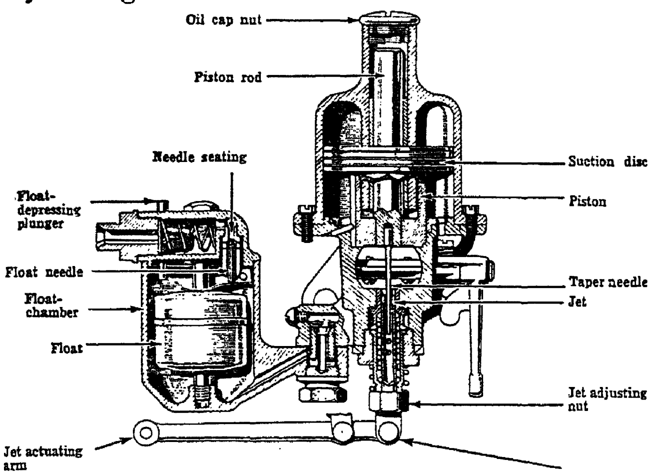


Fig. 66.—The S.U. Controllable Jet Carburettor.

In this carburettor the petrol flow to the jet is governed by a float mechanism of the "top feed" pattern, whereby, as the level of the petrol rises in the float chamber, a lever bearing on the top of the float moves the conical seat "needle" upwards on to its seating, when the petrol supply is shut off.

Petrol from the float chamber is led to a jet, the size of whose orifice is regulated by means of the tapered needle attached to the lower end of the piston shown; this is controlled by the engine suction. As the latter increases the needle is gradually withdrawn from the jet, enlarging the effective opening and permitting it to pass more petrol.

The lower end of the suction-operated piston also functions as a variable choke, regulating the size of the passage in the region of the jet as it rises and falls, thus maintaining a practically constant suction on the jet under varying loads and speeds.

The jet is so mounted that it may readily be moved up or down relative to the tapered needle, in order to weaken or strengthen the mixture over the whole working range, by a lever usually operated from a mixture control knob on the steering column. This control provides an enriched mixture to ensure easy

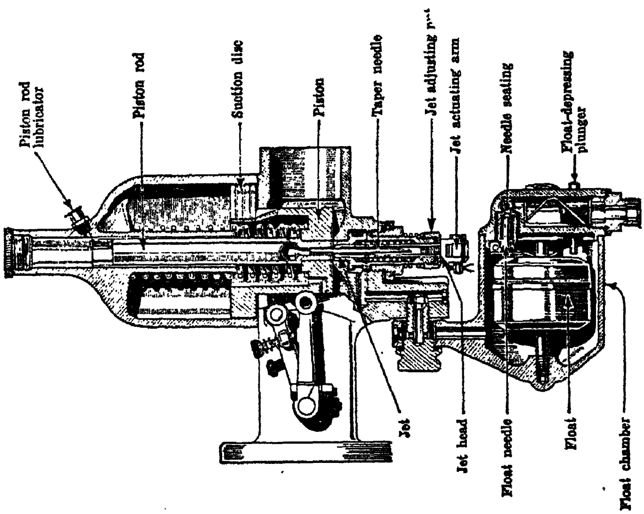


Fig. 67.—The Down Draught S.U. Carburettor.

starting and even running when the engine is cold. When the control is operated, the mixture is "rich". *As soon as the engine has run a few moments it should be released as far as possible without causing the engine to hesitate or splutter through the mixture being too weak from the carburettor when the accelerator is smartly depressed. On no account must the engine be run for any length of time with this control in the "rich" position.* The minimum jet opening can accurately be set by means of the adjusting nut which forms an abutment for the enlarged head of the jet.

The carburettor is extremely simple, and its adjustment is quite easy if it is remembered that the jet is of a fixed standard size and cannot be altered. The only possible adjustment, other than the slow-running adjustment, is the fitting of a new needle of a different size.

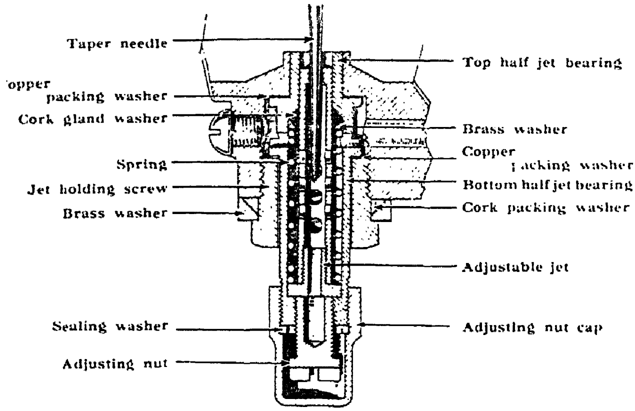


Fig. 68.—Sectional View of Jet Unit of S.U. Carburettor.

Thermostatic Control of S.U. Carburettor.—This method of controlling the variable orifice replaces the ordinary hand control one of the carburettor and employs an auxiliary float chamber attachment to provide the automatic thermostatically-controlled starting and enrichment for the engine warming up period. Referring to Fig. 69, in place of the usual jet head and jet control lever, a short jet (7) is used, which is forced downwards by means of the spring (6) abutting against the jet head (4), the adjusting screw (1) determining the position of the jet, and in order to effect the slow-running adjustment it is only necessary to remove the dome nut (3) which will expose the adjusting screw (1). This should then be screwed up, thus raising the jet until the best idling position is obtained. This operation should, of course, be performed when the engine is at its normal running temperature, that is to say after the thermostatically controlled auxiliary feed is cut out. After adjusting the idling in this way, the dome nut should be replaced, care being taken that the washer (2) is not mislaid when the dome nut is removed.

The auxiliary carburettor consists of an auxiliary jet (C) controlled by a tapered needle (Q), and fed from the main float-chamber (A). Fuel emerging from this jet passes upwards between the shank (D) of the needle and the bore formed in the body through which this passes. Air at the same time enters through the passage (P) and mixes with the jet discharge. The emulsion thus formed is mixed with a further supply of air which passes downwards between a clearance provided between the disc (N) fixed to the needle shank

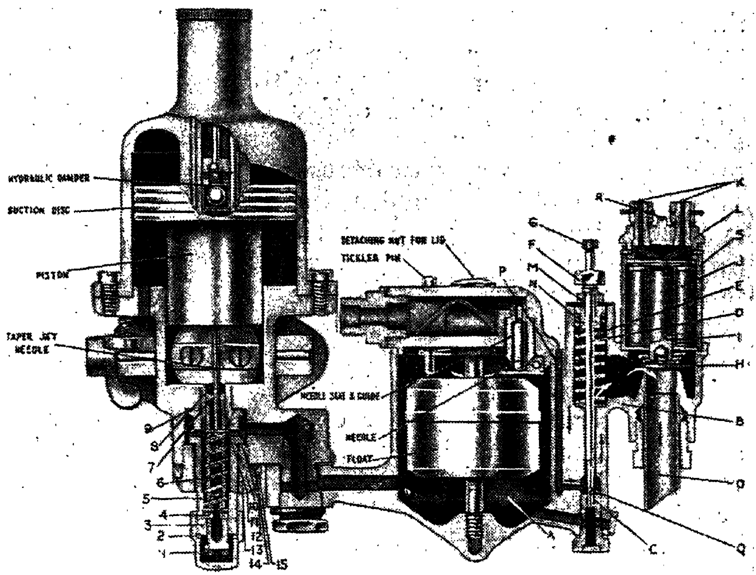


Fig. 69.—The S.U. Carburettor with Thermostatic Control.

(D) and the bore surrounding this disc. This assembly comprising the disc and needle can move vertically and is normally spring loaded upwards by means of the spring (E). The mixture thus formed passes between valve (H) and its seating, and is drawn through the tube (O) into the induction pipe of the engine. It will thus be seen that an additional amount of mixture is drawn directly into the induction pipe irrespective of the main throttle position, and serves to provide the starting mixture, and also to enrichen the mixture

generally, so long as the device is in action. The movable parts (N) and (D) are normally held in the position shown in the diagram, thus when the engine is first started and the suction created in the induction pipe by means of the starter is low, a rich mixture will be provided since the tapered needle (Q) will be withdrawn from the jet. Immediately the engine starts a high degree of suction will be obtained in the induction pipe and consequently a strong flow through the auxiliary carburettor. The high velocity of air passing between the disc (N) and the bore surrounding this will be sufficient to draw the assembly downwards against the action of the spring, and the needle (Q) will therefore enter the jet (C) to a greater extent and diminish the effective orifice of this, thus under these conditions only a moderate enrichment will be provided. In this way an excess of petrol, which will otherwise be obtained under these conditions, will be avoided. Immediately the throttle is opened, however, the induction pipe depression will be diminished and thus the velocity of air past the disc will fall and so permit the assembly to rise again and provide a greater discharge from the jet. The valve (H) is held off its seating by means of solenoid (J) which raises the iron core (I) to which the valve disc is attached, thus so long as a current is flowing through the solenoid this valve will be opened and the auxiliary carburettor will be in action. The current is provided for the solenoid in the following manner:—

One lead is taken from the ignition switch to one of the terminals (K) and the other terminal is connected to a thermostatic switch situated at some point in the water circulating system. This switch is so arranged that when the engine is cold a circuit is provided from the terminal (K) to earth. Immediately the water attains a temperature pre-determined by the setting of the thermostat, the points will open and no return circuit will then be provided, The circuit through the solenoid thus having been broken, the core (I) will be released and valve (H) will return to its seating, thus putting the whole device out of action.

The only adjustment provided consists in setting the stop screw (F) which limits the movement of the needle (D). Screwing this down weakens; screwing it up strengthens the idling mixture. The engine having been allowed to attain its normal working temperature, the auxiliary carburettor should be brought into action by short circuiting the thermostatic switch. A convenient means of doing this is to make contact between the terminal in the centre of the switch and the body of the switch by means of a screwdriver. Having done this the throttle should be momentarily flicked open, thus releasing the valve (H), and bringing the auxiliary carburettor into action. The stop screw should now be adjusted upwards to an extent just short of that which will make the engine run unevenly; in other words, the engine should be given the strongest mixture possible, upon which it will fire on all its cylinders.

S.U. Carburettor Troubles and Their Cures.— There are only three troubles which may affect the functioning of the S.U. carburettor.

(1) The piston may be sticking and not functioning properly.

(2) There may be dirt or water in the carburettor.

(3) The float mechanism may have become deranged, and the carburettor is in consequence flooding.

TREATMENT.

(1) The only part of the suction chamber that is in direct contact is the piston rod in its bearing; therefore, should sticking occur, the trouble should always be looked for at this point. To free a sticking piston remove the brass cap from the top of the suction chamber, and pour down the orifice a few drops of petrol, or paraffin, then move the piston up and down a few times by inserting the finger in the air intake. When this is free, pour in a few drops of sewing machine oil.

(2) When this is suspected lift the piston with a pencil. The jet can then be seen. Flood the carburettor by holding up the float-chamber needle, and

watch the jet; if no petrol flows there is a blockage. To remedy this start the engine, open the throttle and block up the air inlet momentarily without shutting the throttle; keep the throttle open until the engine starts to race. If this method does not effect a cure, the only alternative is to remove the jet and to clean the same: this should only be done, however, after everything else tried has failed.

(3) The only treatment in this case is to dismantle the float mechanism and ascertain whether the latter is out of order or the float is punctured; in the latter case a re-soldered or new float will be the remedy.

In connection with the setting of the jet needle, the correct normal position for this, in the later model S.U. carburettors, is with the shoulder flush with the face of the piston.

Attention should occasionally be given to the petrol filter, which is behind the banjo-type union at the junction of the petrol pipe to the float chamber lid; it is released by unscrewing the large hexagon nut.

Adjusting the S.U. Carburettor.—The methods employed on the Morris and similar pattern S.U. carburettors are as follows:—

Run the engine until it attains its normal running temperature. Set the slow-running control to the right of the steering column so that the engine idles fast. Disconnect the mixture control wire from the end of the brass lever actuating the jet, and screw the jet adjusting nut well downwards. Note that the jet actuating lever is kept in contact with the jet head by its return spring, and must be kept in contact during the whole of the adjusting process. The jet adjusting nut should now be screwed upwards slowly (thus gradually weakening the mixture) until the engine idles evenly, firing on all cylinders regularly, and running at its best speed. This will be the normal slow-running position when the engine is hot, and as the jet needle is of the correct size the general performance of the carburettor on the road should be entirely satisfactory. The mixture control wire may now be reconnected to the jet

actuating lever, care being taken to see that the control thumb lever has ample clearance when the jet is in contact with the adjusting nut.

Final adjustment for slow-running is then carried out by completely raising the throttle control thumb lever so that this control is quite clear of the

Fig. 70.—Adjusting the Slow-running Screw on S.U. Carburettor.

accelerator control, and adjusting the carburettor throttle lever stop screw, which is spring-loaded for screwdriver operation, until gentle slow running is attained.

The Amal Light Car Carburettor.—The Amal carburettor as previously fitted to light cars, is illustrated in Fig. 71.

The special features of this carburettor are: (*a*) That it is accessible—all jets can be removed with an ordinary spanner without disturbing any other part; the main jet can actually be removed while the engine is running on the pilot jet; (*b*) it has no flat spots; (*c*) It gives good acceleration with full power; and (*d*) an economising device is fitted which enables a slightly weaker mixture to be supplied for summer running. This is obtained by unscrewing the small knurled knob (approx. $\frac{11}{16}$ in. dia.) in the L.H. side of mixing chamber to its full extent. For winter running this should be screwed up tight.

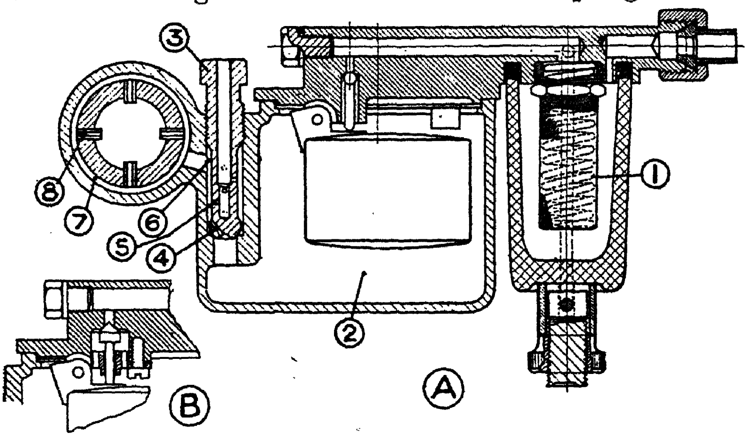


Fig. 71.—The Amal Carburettor.

Fuel, before entering the float chamber, has to pass through the large filter gauze (1) and into the float chamber (2) being adequately cleansed before entering the carburettor. Diagram B is an enlarged view of the float mechanism and valve.

The fuel for the main jet system has to pass through the main jet (3) being metered through the small orifice (4) at the side of the jet.

The main jet contains besides the fuel metering orifice an air passage down its centre with five side outlets (5). This air not only aids atomisation, but chiefly serves another purpose—that of compensation. When the engine's speed increases under light loads this admission of air enables an increased amount of air to flow, owing to its density being lighter than

that of the fuel, and this automatically compensates the tendency for a greater fuel flow. A reverse state of affairs occurs under opposite conditions.

It will be seen that a preliminary mixing of air and fuel takes place in the main jet well (6), and this mixture then passes to the groove (7) round the choke tube.

Owing to the special design of the choke tube the air passing through it to the engine has a high velocity, and as the fuel emulsion issues from the choke tube groove into the air stream from every side through the small diffuser tubes (8), it becomes very intimately mixed with the main body of air.

A pilot jet (9) is fitted for slow running, and means are provided for varying the strength of the mixture supplied by the pilot jet.

The Amal Pump Carburettor.—This carburettor resembles in its general principles certain other carburettors, in having main and pilot jets, diffuser tubes, a bridging or by-pass orifice near the closed position of the butterfly throttle valve, overhead petrol supply system to float chamber, mixture adjustment and quantity screws (Fig. 72).

In addition, however, it is fitted with an important petrol pump action for giving better acceleration and for supplying the correct mixture requirements when the throttle is suddenly opened.

Whenever the accelerator is depressed violently, the pump forces petrol into the choke, enriches the mixture and maintains the richness until the engine has gained the required speed. The response to the throttle is immediate, and the constructional features are such that the pump can be brought into action. or made to cease working, at the moment required.

Once set, the pump is automatically controlled from the throttle spindle.

As the pump enriches the mixture when quick acceleration is required, the carburettor can be set to give a weaker mixture for normal running than if the pump was not fitted.

Owing to the pump, the engine does not depend entirely on its own suction to draw fuel from the carburettor jets, and, therefore, a larger carburettor choke can be used, with the result that the power output is increased.

The action of the carburettor is illustrated in Fig. 72. When the throttle is opened the pump piston 1 is depressed to the bottom of the pump chamber 2. On releasing the throttle lever the pump piston is drawn back to the top of the pump chamber. The suction created lifts the ball-valve 3 from its seating and draws petrol from the float chamber 16 through the passages 4 and 5, filling the pump chamber 2.

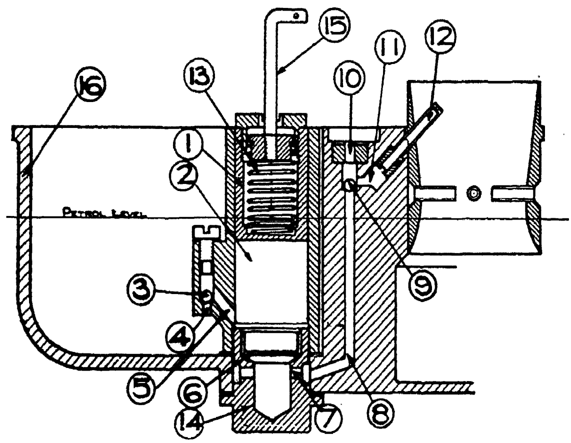


Fig. 72.—Illustrating principle of the Amal Pump Carburettor.

On depressing the pump again (by violently opening the throttle), the piston forces the petrol in the pump chamber through the filter 6 into the passage 7 and upwards along the passage 8, lifting the ball-valve 9 until it rests on the upper seating 10. The petrol then passes along the passage 11, and through the pump jet 12 into the choke, where it mixes with the main air stream.

Should the throttle only be opened slowly the pressure of petrol from the pump chamber will not be sufficient to raise the ball-valve 9 as far as the upper seating, and when this happens the petrol simply flows past the seating, through passage 10,

and returns to the float chamber. This latter action thus prevents the jet 12 acting as a running jet, with a consequent economy in fuel.

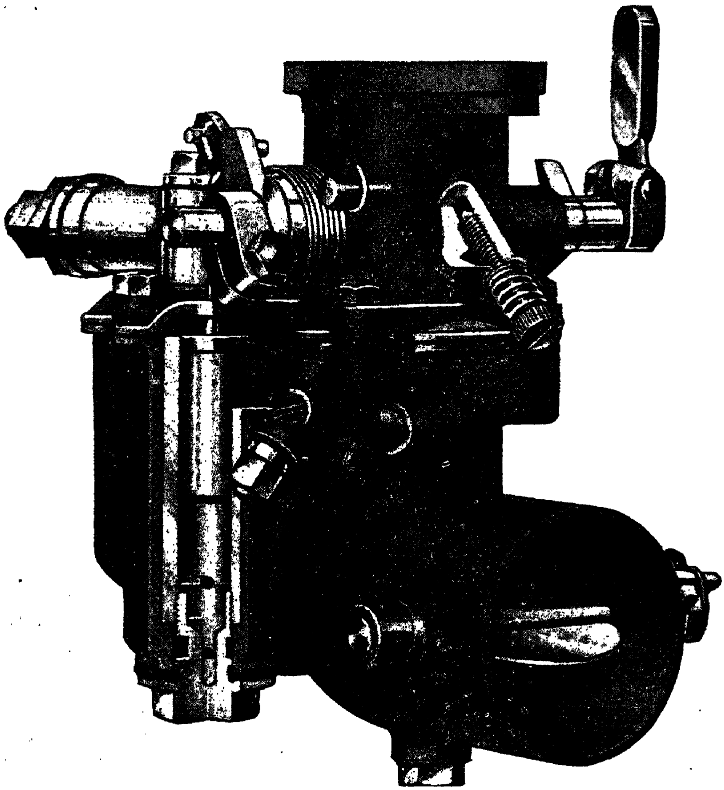


Fig. 73.—The Amal Pump-type Carburettor. (Vertical Model.)

The action of the piston is slowed down slightly by means of a coil spring 13 attached to the piston rod and inside the pump piston, and the speed of the piston is also governed to a certain extent by the size of the jet 12.

The pump piston rod 15 is actuated by a floating lever, in turn operated by another lever, adjustably fixed on the main throttle spindle.

Under normal running conditions the engine cannot draw petrol from the pump jet, owing to the air leak through passage 10.

The Amal carburettor is accessible to a marked degree; all the jets can be removed without disturbing any other part of the carburettor. The main jet can actually be removed whilst the engine is running.

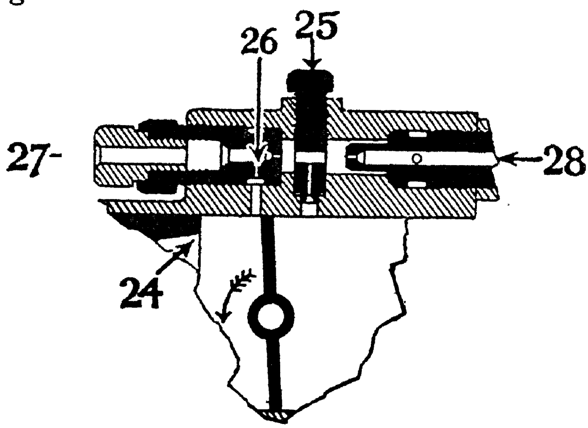


Fig. 74.—The Amal Bridging Jet. 24, Choke. 25, Idling Jet. 26, Bridging or By-pass Orifice. 27, By-pass Air Jet. 28, Pilot Jet.

The *choke diffuser* device of this carburettor consists of a choke tube into which protrude the four diffuser tubes. This ensures that atomisation of the petrol occurs twice, first, as the petrol issues from the petrol orifice in the main jet into the jet chamber, there mixing with a small amount of air. This is further atomised on issuing into the main air stream through the choke.

To obviate a "flat spot" when changing over from the pilot to the main jet, a special "bridging jet" is arranged around the throttled "closed" position. This is shown in Fig. 74.

The Sthenos Carburettor.—This Belgian designed carburettor has been used on cars for a long period, and has a good reputation. It belongs to the submerged jet class, but possesses special features. The working of this carburettor can be followed from the illustration (Fig. 75), the latter does not show the constructional details of the latest type, with which, however, we are not primarily concerned.

The main jet is shown at C; it is held in place by the conical seating A, and the wing-nut shown below. The jet is of the diffuser type, which allows more fuel to flow at low, and less at high speeds than in the case of the ordinary single-jet type carburettor, thus tending to maintain the mixture uniform in proportions. The "well" communicates with the

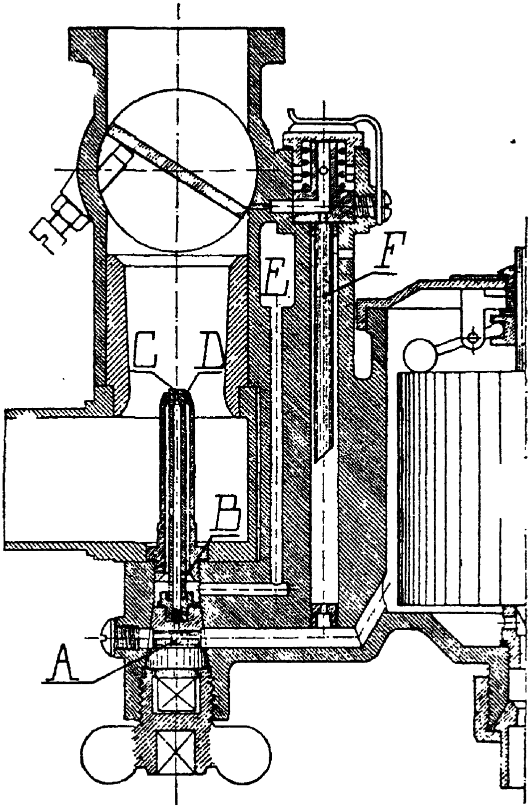


Fig. 75.—The Sthenos Carburettor.

atmosphere at E; the auxiliary or compensating jet D is supplied with fuel through the restriction B. As the engine speed increases the level of the fuel in D falls, due to the restriction failing to supply fuel fast enough, and this exercises a compensating action to the excess which tends to flow from the main jet C.

The pilot jet F consists of a dipper tube normally immersed in the fuel communicating with a small port on the engine side of the (closed) throttle; air is admitted above the dipper portion through small holes in the side. When the throttle is nearly closed

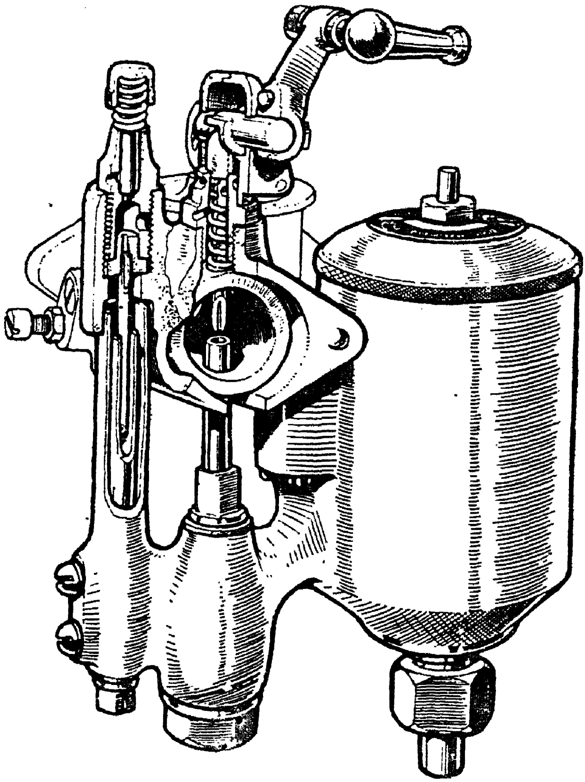


Fig. 76.—External View of the Sthenos Light Car Model Carburettor.

a strong suction is exerted on the pilot jet, but as the throttle is opened, the main jet C comes into action and uses up the fuel in the pilot well, until at a certain speed the lower end of the dipper F is uncovered, and no more fuel flows up it; the pilot jet is then cut out of action. The accessibility of this carburettor is a good feature. The main jet can readily be removed by unscrewing the wing-nut below, and the pilot jet unit by moving the spring clip shown above F.

In the latest type instrument (Fig. 76) an adjustable pilot jet is fitted, and also a special main jet mixture control, in the form of a conical tube over the main jet opening, which can be moved nearer to or away from the latter by means of a lever-operated cam.

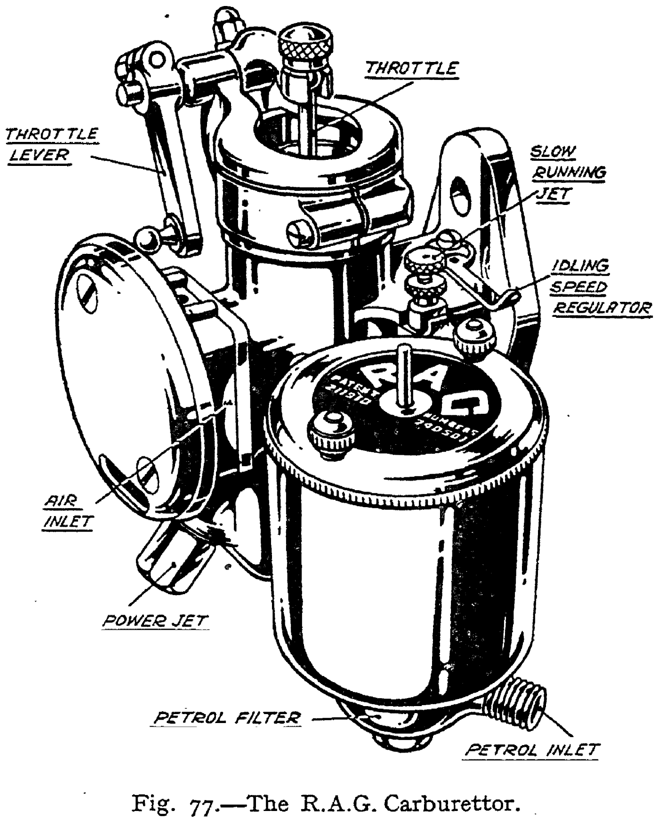


Fig. 77.—The R.A.G. Carburettor.

The R.A.G. Carburettor.—This British carburettor, which was fitted to several makes of car, had certain novel features as shown in Figs. 77 and 78; it was particularly accessible for adjustment and dismantling.

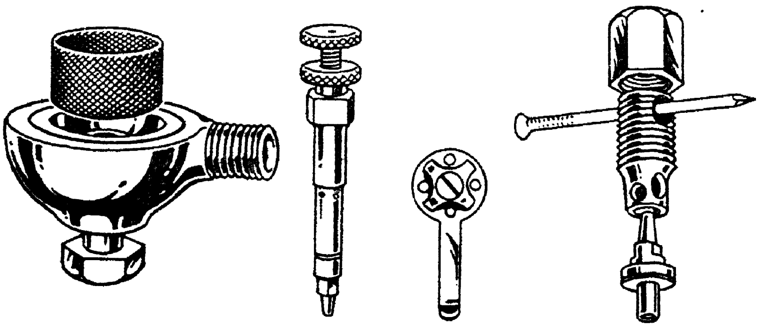
There was a main and power jet, and a pilot jet for slow running; the latter was readily adjustable by removing it bodily and altering a screw device on the top before replacing.

The main and power jets were also easy to remove after the cover caps have been taken off, merely by using a piece of wire or a nail as shown at *D* in Fig. 78.

The petrol filter was fitted below the float chamber; it could be detached by removing a single screw (6).

An adjustable screw device was fitted for regulating the quality of the mixture; the mixture is enriched when the device is screwed in. (Diagrams B and C., Fig. 78.)

A plunger type of throttle (Fig. 77) was fitted. It was operated by means of an elbow lever, the position of which could be altered to suit the control rods.



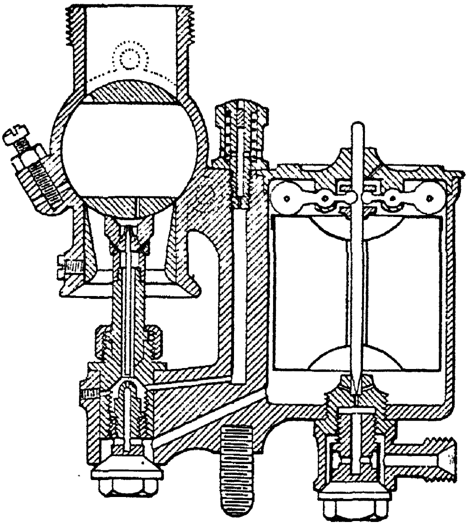
A B C D

Fig. 78 A. Component Parts of R.A.G. Carburettor. *A*, Petrol Filter. *B*, Slow-running Jet. *C*, Idling speed regulator. *D*, Showing Method of removing Jets.

An idling speed regulator was fitted for slow-running purposes; the adjustment was carried out by rotating the lever provided in either direction. When adjusting this carburettor for starting or idling *the throttle must be completely closed.*

The Longuemare-Hardy Carburettor.—The Longuemare carburettor, of French origin, had a long period of use, and was very popular on British and French cars. This carburettor belongs to the submerged jet class, with a separate pilot jet, supplied with fuel from the main jet channel. In the ordinary car type carburettor there is a variable adjustment for the fuel supply through the equivalent of the restricted

orifice, a milled screw being provided in the centre of the float chamber. The air supply to the pilot jet can also be regulated by means of a screw provided. The reserve fuel chamber is arranged in the centre of the float chamber and is provided with the usual atmospheric hole in the top.



. 79.—The Longuemare-Hardy Carburettor.

Fig. 79 illustrates in section the light car model. This differs from the ordinary car model in having no variable needle valve for the fuel supply (or restricted orifice), although different jets can be supplied for varying this fuel supply. The fuel enters from below into the float chamber, through the ordinary needle valve mechanism, and flows down a sloping passage to the restricted or submerged jet, which has an air communication seen in the centre, leading to the right, just above the jet mentioned. The main jet terminates in a special atomizing device consisting of a male and female cone, almost touching, and provided with fine serrations, to allow the fuel to flow out in fine jets in the form of a "rose." The pilot jet is in the centre of the main jet, a small hole being left in the cylindrical throttle for the pilot jet mixture. There is a regulating screw for varying the quality of the pilot jet mixture.

In the ordinary car model a special feature is the pilot jet clearing device. By simply pressing up the button provided at the bottom of the carburettor, a needle passes up the pilot jet and frees it from obstruction. The fuel supply to the pilot jet passes up a very fine tube, whilst the air flows in through the side of the main carburettor, through a regulable

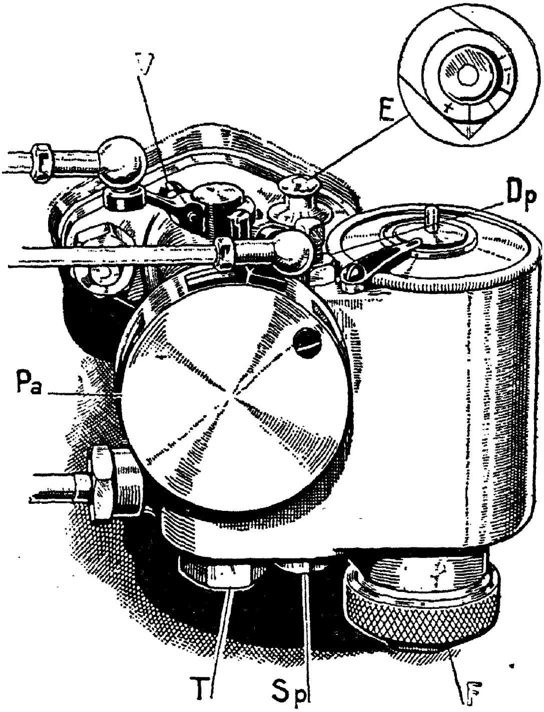


Fig. 80.—Fiat Carburettor. *Dp*, Slow running choke screw. *E*, Economiser. *F*, Petrol filter. *Pa*, Adjustable cold air inlet. *Sp*, Pilot jet. *T*, Main jet plug. *V*, Throttle stop screw.

orifice, the resulting mixture flowing into the centre of the throttle through the small hole shown, and thence to the engine through another regulable small opening in the upper part of the throttle.

The Fiat Carburettor.—Fig. 80 illustrates the type of carburettor fitted to certain Fiat car engines. This carburettor has a slow-running choke-screw *Dp*, petrol

economiser *E*, and adjustable cold air inlet *Pa*. The main and pilot jets are shown at *T* and *Sp* respectively A petrol filter *F* is arranged under the float chamber. The slow-running position is adjustable by means of the throttle stop screw *V*. It will be observed that the petrol economiser *E* has a graduated ring and moving pointer to assist in making adjustments and recording the position of same.

In another model Fiat carburettor the economiser has a milled screw and slot to alter the adjustment.

The Memini Carburettor.—This design has been somewhat extensively used on Italian racing and touring cars, and has also been manufactured in this country. It belongs to the submerged well class, with separate pilot jet for slow running, operated by a single lever. Fig. 81 shows the carburettor in cross-section, through the float chamber and venturi-tube: the axis of the latter is perpendicular to the plane of the paper. Referring to this illustration, A is a plain diffuser tube which is surrounded by an annular sleeve B. Between A and B is a space, connecting *via* small holes C in diffuser to passage D; this connects through the small passage E to space F. Here is found the maximum or main jet G. The diffuser tube A is in communication with the main jet *via* passage H, which is larger than passage E. J is a pilot or slow-running jet which communicates *via* passage K to the by-pass at the butterfly throttle. L is the needle valve adjustment for slow running. The normal petrol level with the engine stopped will be along the line MM, which is approximately 2 mm. to 4 mm. from the top of the diffuser tube A.

The throttle is slightly opened for starting to allow the by-pass to draw petrol along passage K, from the pilot jet J. If the throttle is opened wider, the diffuser tube A comes into action, and the petrol standing in H and F is at once drawn up the diffuser, giving an effective acceleration. When this has taken place the spraying is effected through main jet G and the compensating device will come into play. That is, the suction up the annular space between A and B will be communicated *via* D

and E to F and will oppose the suction of the main diffuser along H with a lesser retarding suction. In order to supply a flow of air up the space the passage

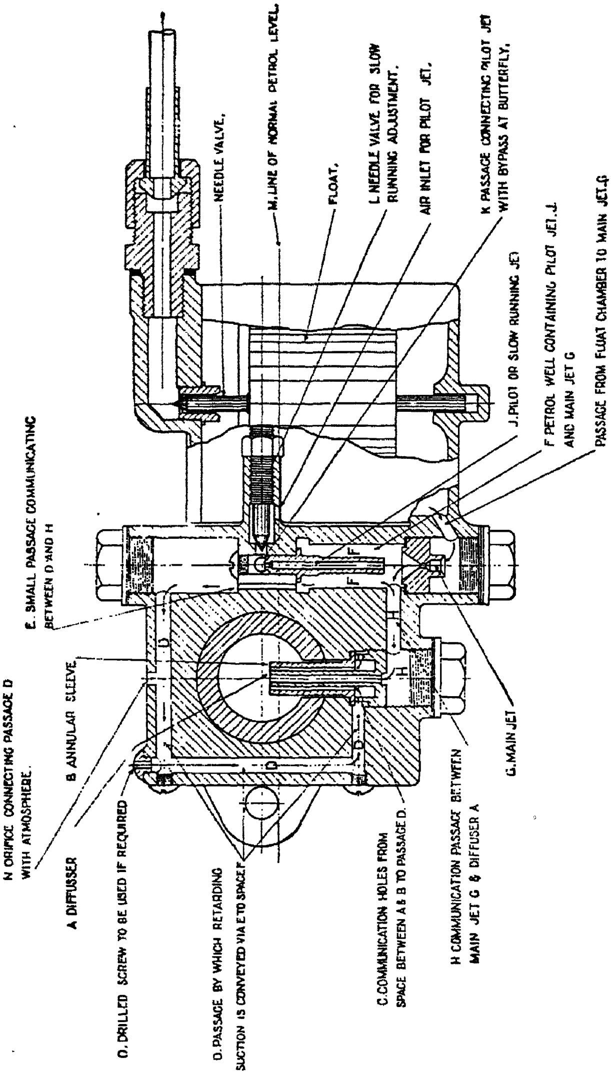


Fig. 81.—The Memini Carburettor.

D communicates with the atmosphere through the aperture N. It is sometimes found possible to give another vent for air through the screw at O—these

screws are supplied with various sized holes. The effect of this may be to slightly weaken the mixture, as with N and O forming a comparatively large area, air may be drawn down E and along H into the main diffuser. If this causes "popping back" or loss of power put back the blank screw. This is assuming that everything was right before the drilled screw was fitted. A pilot jet of suitable size is found, and the position of L is obtained by trial. Opening L reduces the suction on the pilot jet. If it is found necessary to have the needle valve right closed, a larger pilot jet should be used. If the engine, when running slowly, does not run evenly, it is usually a sign that the needle valve wants opening. If fully opening L is not an improvement, fit a smaller pilot jet.

The petrol spray is mixed with air in two stages when the engine is running at average speeds. It is drawn through G and sprayed along H in the form of a mist. Here it is mixed with a small quantity of air drawn through E and up the diffuser tube, where it mixes with the air passing up the space between B and A, and main air flow passing through the choke or venturi-tube.

Adjustment is carried out by changing the main jet and diffuser tubes; usually each of the former has a corresponding size of the latter. In addition the choke-tube can be changed. The sizes supplied vary from No. 22, for small cars of about 7 H.P., up to 48, for 40 H.P. cars.

The Rolls Royce Carburettor.—Rolls Royce cars up to 1936 were fitted with special carburettors designed and developed to a high state of efficiency by the manufacturers.

The 1937 and subsequent models were, however, fitted with carburettors operating upon the Bendix Stromberg principle; an illustration of the 25/30 h.p. Rolls Royce carburettor will be found on p. 173.

The 40/50 twelve-cylinder vee-type engine uses a similar make, but of the dual choke tube design.

The Rolls Royce make of carburettor is shown in position in Fig. 82.

The special features of this carburettor system include an exhaust-jacketed induction pipe, steering wheel position controlled jets, automatic expanding

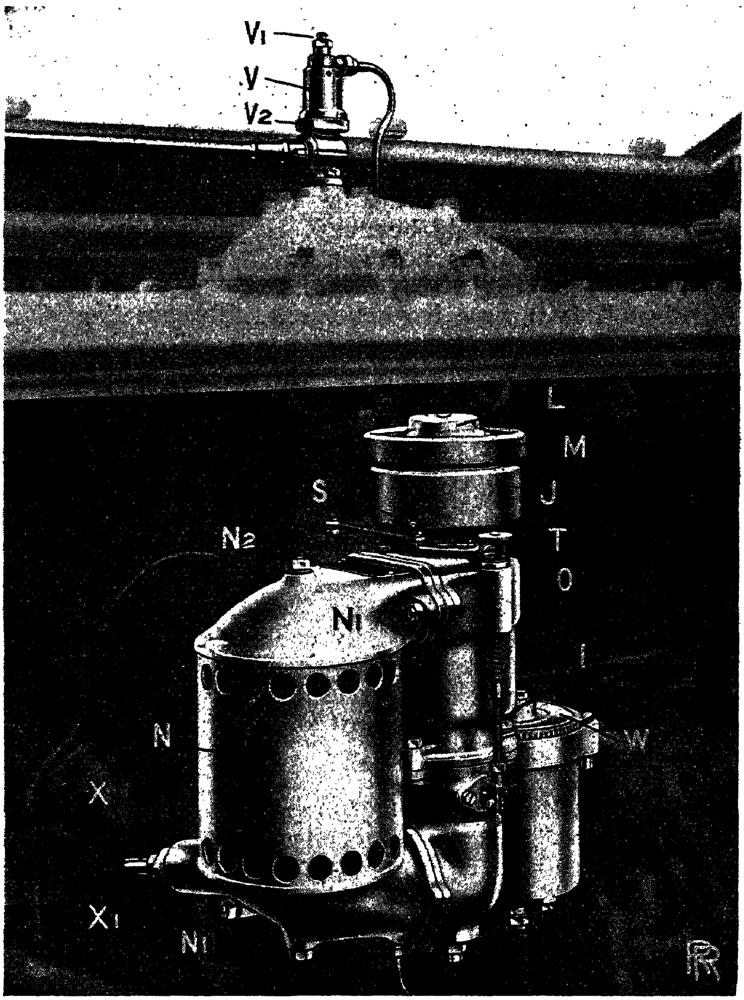


Fig. 82.—The Rolls Royce Carburettor

action by means of a suction-operated piston, an auxiliary starting carburettor—this is shown at *V* and crankcase breather pipe leading oil fumes direct to the carburettor intake.

Referring to Fig. 82, the carburettor is provided with two jets controlled by a single lever mounted on the steering wheel. Each of these jets is located in a venturi-tube, the smaller one always being in action, and the larger one being automatically brought into action by an increase beyond a certain value in the depression inside the carburettor.

The outlets of the petrol jets are regulated by taper needle valves, one for the small or low-speed jet, and the other (shown at *I*) by a high speed jet needle.

The automatic expanding effect is attained by the provision of a suction-operated piston working in a cylinder *J*, located above the high-speed jet. The cap *L* contains a "return" compression spring.

Increased depression in the carburettor raises the piston against this spring, carrying with it a diaphragm which fits into, and in its lowest position blanks off the largest choke tube. The lifting of this diaphragm admits air past the high-speed jet. More movement of the piston not only opens the high-speed choke tube further, but also admits air by uncovering special ports in the cylinder *J*; this counteracts the tendency for the mixture to become over-rich at increased air velocity. The ports open into the air silencer *N*, which acts also as an air cleaner.

The mixture control lever, which operates both jets simultaneously, provides ample range to suit ordinary variations, such as those of temperature, external air pressure *and the use of different fuels*.

The auxiliary starting carburettor is arranged on the induction pipe as shown at *V* (Fig. 82); it is controlled from the dashboard by means of a small lever mounted on the latter. The starting carburettor control is inter-connected with the control of an extra oil supply to the cylinder walls, the dial of the control lever being marked "Starting," "Running," and "Extra Oil Only." The extra oil supply is also turned on in the "Starting" position. The object of this is to counteract any tendency for the pistons to be under lubricated when starting from the cold. The lever is turned to the "Extra Oil only" position as soon as the engine starts, and left there until the radiator thermometer records a temperature of about 50° C.

Petrol is drawn through a small pipe from the main carburettor float chamber, and air through the holes around the starting carburettor. A spring controlled piston in the latter is operated by engine suction, and regulates the air supply to suit the degree of this suction.

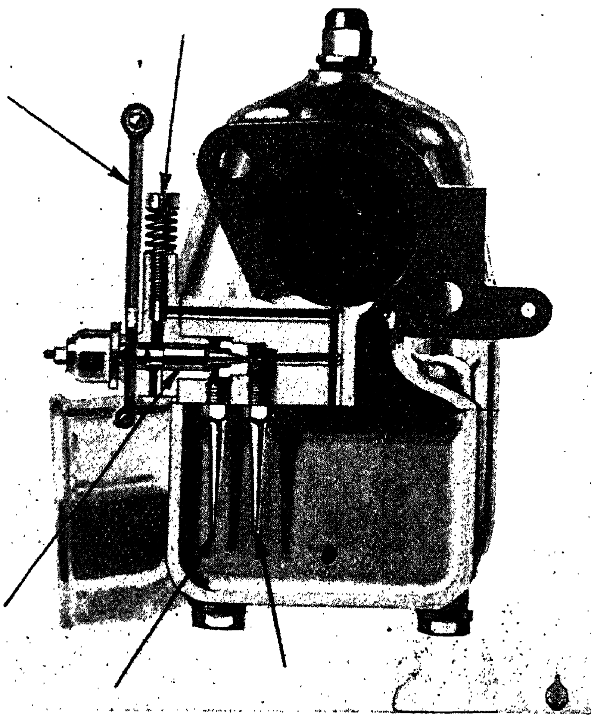


Fig. 83.—The Daimler Carburettor, showing the Petrol Primer and Slow Running Jets.

The petrol supply can be adjusted by rotating the screw V_1 at the top of the starting carburettor, which carries a taper jet needle. Screwing this down weakens the starting mixture, and, conversely, unscrewing it enriches the mixture.

The Daimler Carburettor.—The earlier Daimler carburettors all utilized the multiple-jet system, whereby each of a series of five jets, in its own choke

tube, was uncovered in turn by a sliding sleeve operated by engine suction.

The later Daimler engines also used carburettors working on the same principle, but various refinements are incorporated in these.

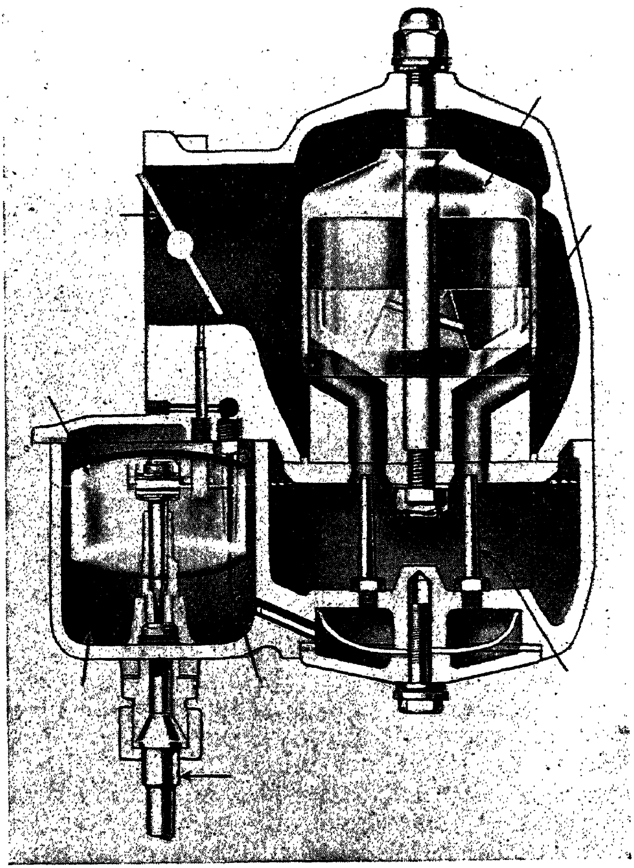


Fig. 84.—The Daimler Carburettor, showing the Float Chamber, Sliding Sleeve and Jets.

In the largest Daimler cars, however, either the Stromberg or Solex carburettors are fitted.

Referring to Figs. 83 and 84, which show the particular model fitted to the 20/30 h.p. models, it will

be observed that in addition to the main jets and the choke-tube block, which is shown in Fig. 84, with its sliding sleeve, there is also a separate inverted slow-running jet which supplies petrol to a small orifice on the engine side of the throttle valve, in its closed position. Air is also drawn in with this petrol to give the correct mixture for slow running. There is also *a primer jet* (shown in Fig. 83) for starting purposes. On opening the primer valve, by means of a handle on the dashboard, the air supply to the slow-running jet is cut off and the primer jet is brought into operation. This enriches the mixture sufficiently to compensate for the weakening effect caused by condensation on the cold walls of the induction pipe.

An air intake shutter is also fitted to the air inlet pipe. The more this is closed the more is the air drawn from the vicinity of the exhaust pipe. Normally it is kept fully opened, but on very cold days it is partially closed.

In connection with the main jets of the Daimler carburettor it should be mentioned that the sleeve begins to float immediately the starter motor is put into operation, and its effect is to maintain a constant vacuum in the mixing chamber by uncovering more tubes as the power and speed of the engine increase. A constant vacuum in the mixing chamber provides the best conditions for the operation of the carburettor.

The number of jets in the Daimler carburettor is fewer than the number of tubes, some of which are only air passages. At the base of the tube block is a detachable choke plate with holes corresponding in position to the tubes, but of smaller size. The tips of the jets project into these chokes and the richness of the mixture depends on the size of the jets in relation to the size of the effective air passage through the choke plate.

The Ford 8 and 10 H.P. Carburettors.—The Ford carburettors are designed by the firm in question and are of the down-draught pattern, automatic in action to give uniform mixture conditions over the speed range.

The principal parts of the carburettor are illustrated in Fig. 85.

The quantity of petrol entering the carburettor from the fuel pump is governed by means of a float and valve so designed as to maintain a correct fuel level at all times. The float level should never be altered for any reason.

The carburettor jet sizes are fixed and are selected to give the most satisfactory operation over the entire range of engine speed.

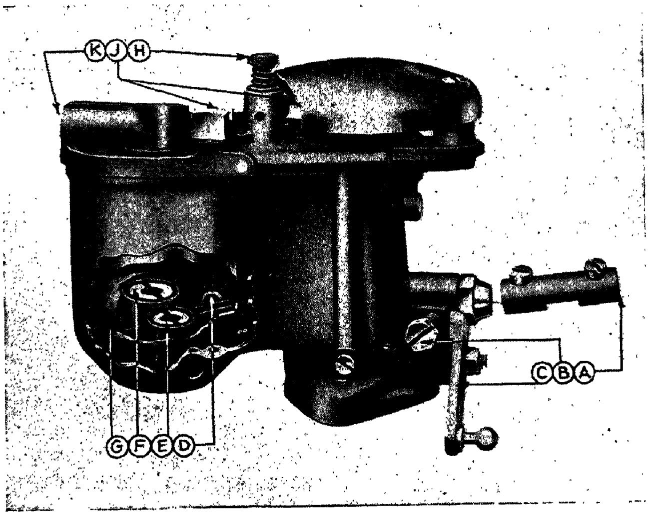


Fig. 85.—The Ford 8 and 10 h.p. Carburettor.

A, Starting Control. B, Throttle Adjusting Screw. C, Throttle Lever. D, Starting Jet. E, Main Jet. F, Compensating Jet. G, Float. H, Air Adjustment Screw. J, Float Chamber Screws. K, Petrol Inlet.

The only thing likely to affect the operation of the carburettor is the presence of dirt or water in the float chamber or jets. Should it become necessary to obtain access to the jets for cleaning purposes, this may be done by undoing the two square-headed screws (J) on top of the float chamber (see Fig. 85) when the float-chamber bowl, complete with the jets, can be removed. The main and compensating jets will be found in the bottom of the float chamber, the slow-running jet is located on the rear edge of the bowl at

the top and the starting jet on the outside of the float chamber in front of the starting device. These jets are all provided with screwdriver slots, permitting easy removal, and should be cleared by blowing through them. A pin or piece of wire should not be used for clearing, as this will destroy the accurately calibrated orifices and upset the operation of the carburettor. Under no circumstances should the emulsion block (the die-cast plate held by three screws to the rear face of the float chamber and carrying the nozzle which projects into the venturi tube) be removed, as it is most essential that this should make an air-tight joint with the bowl.

The carburettor is equipped with a special starting device, which enables the mixture to be enriched sufficiently to ensure easy starting from cold, while at the same time preventing any possibility of raw petrol being drawn down into the cylinders.

The device is actuated by a control located in the centre of the dashboard and need only be used when the engine is cold.

The control should be pulled out and turned clockwise until the engine has warmed up. It should be released by turning anti-clockwise as soon as the engine shows signs of "hunting" or stopping due to over-richness.

Never depress the accelerator pedal when starting. The slow-running position of the throttle obtained when the engine is warm, in accordance with the instructions above, is the best position for starting with either a hot or a cold engine.

Slow-running Adjustment—The only adjustments required are to the throttle-adjusting screw (B) and the air-adjusting screw (H) for idling speeds (see Fig. 85).

The approximate settings are:—

Air-adjusting Screw.—One-half to one full turn open.

Throttle-adjusting Screw.—Screw in about ½ to 1½ turns after the set screw touches throttle lever.

The best adjustment is about ¾ turn open.

To obtain the exact settings for the individual engine, proceed as follows:—

When engine is warm, turn throttle-adjusting screw so that engine will run sufficiently fast to prevent stalling. The air-adjusting screw should next be turned in or out until engine runs evenly; the throttle screw may now be readjusted if engine is running too fast, followed by a further readjustment of the air-adjusting screw. These operations should be repeated until idling speed is satisfactory.

The Down-Draught Carburettor.—Attempts have been made in the past to improve the efficiency of the engine by making the inlet ports and passages between the carburettor and the cylinders as short and as smooth as possible. Thus, the *horizontal type* of carburettor, with its straight through passage

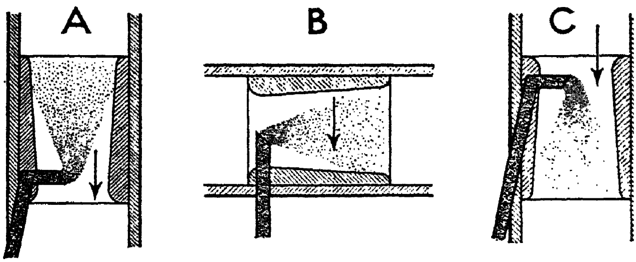


Fig. 86.—Three Carburettor systems.

was evolved as an improvement upon the vertical type, and in most cases there has been a gain in volumetric efficiency when horizontal carburettors have been fitted.

Both the horizontal and vertical carburettor types have now been replaced largely, in automobiles, by the *down-draught* pattern (some examples of which have already been mentioned) which is mounted above the induction ports, in such a manner that the air for the carburettor is drawn vertically downwards past the jet. The petrol issuing from the latter is therefore assisted by gravity to enter the engine.

It is of interest to examine the three systems referred to; these are shown, diagramatically, at A, B and C, respectively, in Fig. 86.

Diagram A shows the vertical carburettor system in which the fuel is drawn from the jet against the force of gravity. In the horizontal type, shown at B, the weight of the fuel tends to deposit it on the bottom of the choke. In the down-draught type C, however, the force of gravity assists the petrol into the induction manifold. The two former types, A and B, are fitted with smaller choke tubes than are theoretically necessary, in order to prevent precipitation and to ensure sufficient velocity of air past the jets to give proper carburation even when the throttle is wide open and the engine suction is a minimum.

It is unnecessary, however, to employ such small chokes in the down-draught carburettor for the carburettor can operate satisfactorily with a lower depression, owing to the gravity effect of the weight of the fuel in entering the induction manifold.

The result of using larger chokes in down-draught carburettors is to enable a greater weight of mixture to be passed through to the engine at full throttle and at high engine speeds. The volumetric efficiency is, therefore, higher on this account.

In addition, it is found that the engine will pull better at the lower speeds under load, as the fuel is fed largely by gravity into the induction ports, under these conditions.

Another practical advantage is that the carburettor is rendered more accessible, and since it is usually well out of the way of the valve tappets, the latter can be adjusted more readily.

In view of its advantages over the horizontal and vertical types, the down-draught pattern carburettor is now made by all carburettor manufacturers, and has become the standard pattern on the majority of recent motor cars.

In connection with the use of larger chokes, since the mixture reaches the cylinders more rapidly, it is generally found necessary to provide some additional heating, in order to assist vaporisation; otherwise the mixture would enter the cylinder in a rather "wetter" condition.

When considering the fitting of down draught carburettors, the question of mixture heating, by suitable "hot spots," exhaust or hot-water jackets, should therefore be taken into account.

Down draught carburettors appear to be more sensitive to an over-cooled engine or to induction passage design than the vertical type of carburettor.

There are certain factors that must be taken into account when fitting down draught carburettors, viz.:—

(1) The possibility of jet leakage going direct into the inlet manifold, or cylinder, should the jet overflow through a defective float.

(2) The raising of the float chamber of this type of carburettor reduces the head of petrol between the vacuum tank, in the case of earlier models, and the float chamber, so that there may be some risk of petrol starvation on hills if this point is not safeguarded against.

The use of petrol pump feed systems obviates this difficulty, however, by ensuring a positive feed of petrol to the carburettor under all conditions of running.

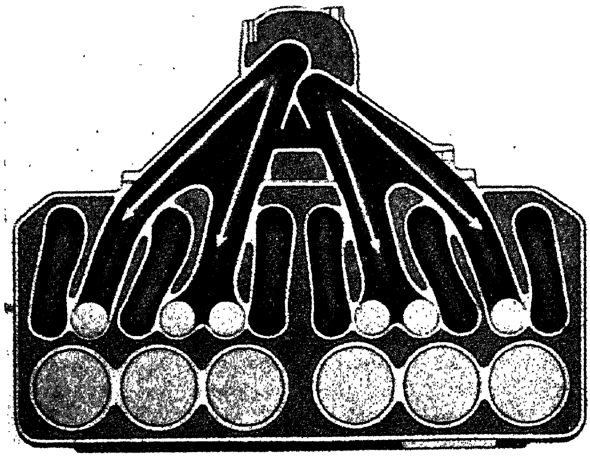
(3) The inlet passages and valve ports must be adequate in size and as short and free from bends as possible; otherwise little, if any, advantage may be obtained with down draught carburettors.

Dual Carburettors.—Whilst the single carburettor is satisfactory for the smaller sizes of four- and six-cylinder engines, it does not give the proper mixture distribution, nor the highest possible volumetric efficiency in the case of larger sizes of engine.

It is becoming the custom, therefore, to fit a special type of carburettor, known as the "Dual" one to engines of the six- and eight-cylinder class, in the 20 h.p. rating class and above.

The dual carburettor should not, however, be confused with the *multiple carburettor* system, whereby a separate carburettor is provided for each group

of two, three or four cylinders. In this case each of the carburettors is of identical design, their controls being coupled so as to operate simultaneously.



87.—The Hudson Dual Carburettor Manifold.

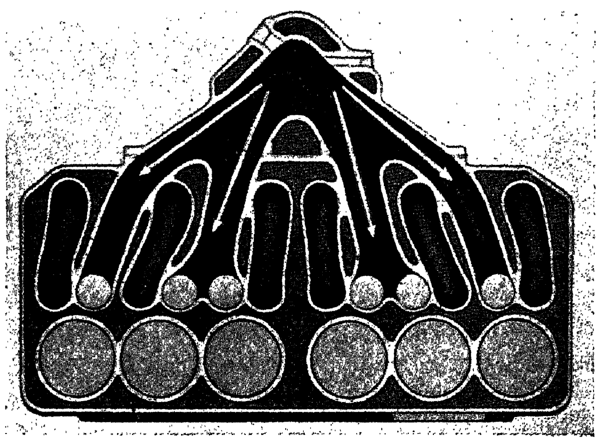


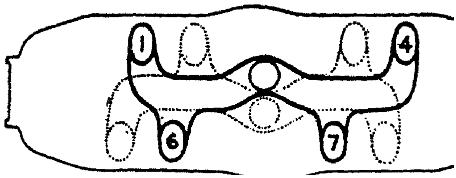
Fig. 88.—The Hudson Single Carburettor Manifold.

The dual carburettor, however, takes the form of a single carburettor unit having a common float chamber, choke valve and accelerating pump, but

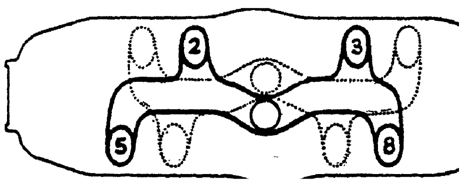
separate manifold passages, each with its own choke tube, main and pilot jets. Each outlet passage is independent of the other, and supplies its own group of cylinders.

Thus, in the case of the more recent Hudson six-cylinder engine, one carburettor outlet supplies cylinders Nos. 1, 2 and 3, and the other outlet, Nos. 4, 5 and 6. (Fig. 87).

The dual carburettor for the Hudson Eight has two separate manifold outlets, one of which supplies cylinders Nos. 1, 2, 7 and 8, and the other, Nos. 3, 4, 5 and 6.



Firing order- Right-hand barrel of carburettor
1, 4, 6, 7.



Firing order- Left-hand barrel of carburettor
5, 8, 3, 2.

Fig. 89.—The Ford Vee-Eight Inlet Manifolds.

Reverting to the example shown in Fig. 88, the performance of the (otherwise unaltered) engine has been improved appreciably, merely by the substitution of the duplex for the single pattern carburettor, and a slight alteration to the inlet manifold, namely, by the addition of a separating partition.

The engine fitted with the single carburettor system shown in Fig. 88 developed 96 B.H.P., whereas the identical engine having the dual carburettor and divided manifold of Fig. 87 gave 101 B.H.P.

This increase in horse power is attributed to the larger effective inlet manifold, which resulted in a

relatively slower mixture flow and higher volumetric efficiency. Moreover, the mixture strength was more uniform in the manifold passages as there was less tendency to throw the fuel out of the mixture due to striking the walls of the passages at high velocities. Another important factor was that the mixture did not have to change its direction to the same extent with the separate manifolds as with the single one, when feeding the different cylinders.

The Ford Vee-Eight engine is also fitted with a dual carburettor, one manifold (Fig. 89) supplying cylinders Nos. 1, 4, 6 and 7, whilst the other supplies cylinders Nos. 2, 3, 5 and 8.

The Buick Compound Carburation System.—The later model Buick eight cylinder engines employ an original carburation system, whereby two dual car-

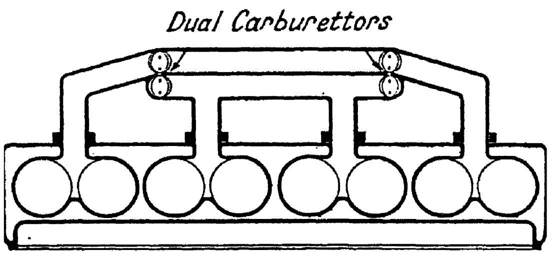


Fig. 90.—The Buick Compound Carburation System.

burettors are used. One of these is a standard carburettor, with the usual choke, starter switch, acceleration pump and power by-pass. The other carburettor is provided only with idling and main carburation systems, throttle and special auxiliary throttle or damper valve; this carburettor is fitted at the rear end of the engine, the standard complete one being at the front. In use the main carburettor is employed for ordinary running and the rear carburettor comes into action when the main carburettor throttle is about half open. As the latter throttle opening is increased the throttle on the rear carburettor opens progressively until for full power purposes both throttles are fully opened. The main carburettor throttle is therefore connected to the driver's accelerator pedal, the rear

carburettor throttle being actuated by a pick-up lever (Fig. 91) with a delayed initial opening. Actually, however, the rear carburettor is controlled by both the throttle position and the air opening (speed) as follows:—On closed throttle, or idling, air passing through the front and rear carburettors draws petrol from the idling systems of both carburettors; there is sufficient clearance around the damper valves to permit the idling system of the rear carburettor to function with the damper valve or auxiliary throttle closed. With the throttle partly open, petrol is fed from the idling systems of both carburettors and the main

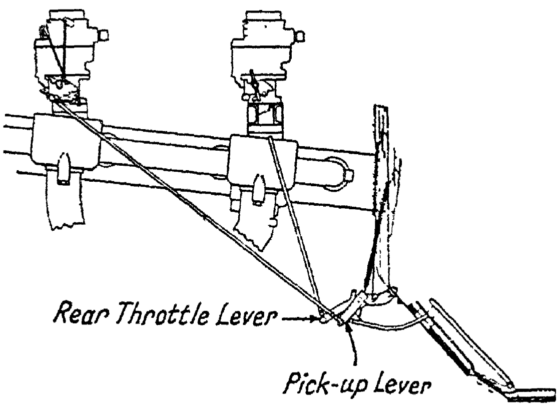


Fig. 91.—Throttle connections for Buick Compound Carburation System.

system of the front carburettor. For full throttle operation, both the main systems are in complete action.

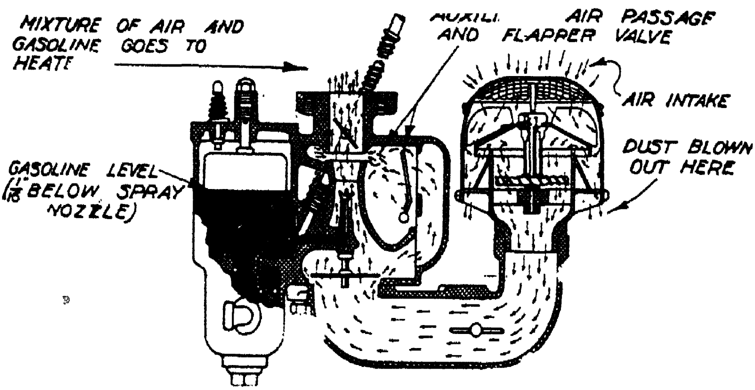
As each of the dual carburettors is smaller (1 in.) than the single dual carburettor needed for the same engine, this system gives a better mixture control over the complete power output range and therefore tends towards greater fuel economy; it also gives a higher maximum output at full throttle opening. Another advantage claimed for this system is greater flexibility than for a single carburettor.

CHAPTER V

AMERICAN CARBURETTORS

American Carburettors.—Speaking generally, the American instrument is rather more complicated, and contains more moving parts and adjustments than those produced in this country.

In consequence of the various joints and pins in the carburettor mechanism, the effect of wear in these is liable to upset the fine adjustments of the carburettor.



OPERATION OF CARBURETTOR.

Fig. 92.—The United Air Cleaning Device fitted to a Franklin Carburettor. The road dust is removed by centrifugal action of the suction operated fan on the right.

There has been a tendency in the past to lower the volumetric efficiency of the engine, owing to the obstacles and restrictions in the carburettor. On the other hand the American carburettor has many refinements not hitherto found on British models of the same period.

The concentric type, or annular-shaped, metal or cork float is very common; it gives a compact, but

usually more complicated casting, but ensures the fuel level in the jet remaining constant when the car is negotiating inclines.

In one or two instances aircraft pattern float chambers are employed; the level of the petrol at the jet remains practically constant under conditions of car inclination, acceleration and retardation; moreover, no surging effects can occur in the float chamber.

The more recent carburettors are of the down-draught pattern, with air cleaners. They are fitted with somewhat complicated devices for mixture regulation, and mostly have automatic main air chokes with damping pistons. Special arrangements are often made for starting from the cold as distinct from warm engine starting.

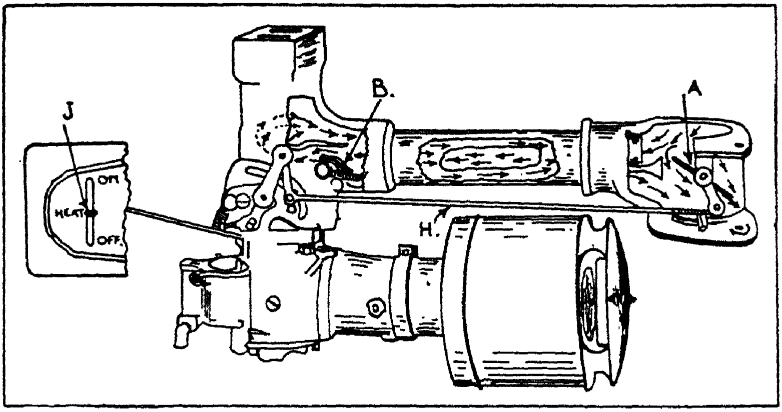


Fig. 93.—The Exhaust Heating Arrangement, with Dash-board Control, of the earlier Buick Carburettor.

Exhaust heated "wells" or hot spots in the inlet manifold are the usual practice; in most cases there is a butterfly throttle in the exhaust duct to shut of the exhaust gases from the inlet manifold heater at the main throttle is opened.

In order to prevent liquid deposition in the inlet "well", special drains with non-return valves are sometimes fitted.

In one or two instances, automatic air inlet valves of the spring-controlled type, are fitted for mixture

compensation purposes; these valves open at the higher engine speeds and supply the "extra air" need to compensate for the enrichening of the mixture. In other cases the air valve operates a tapered needle valve in the petrol jet for mixture compensation.

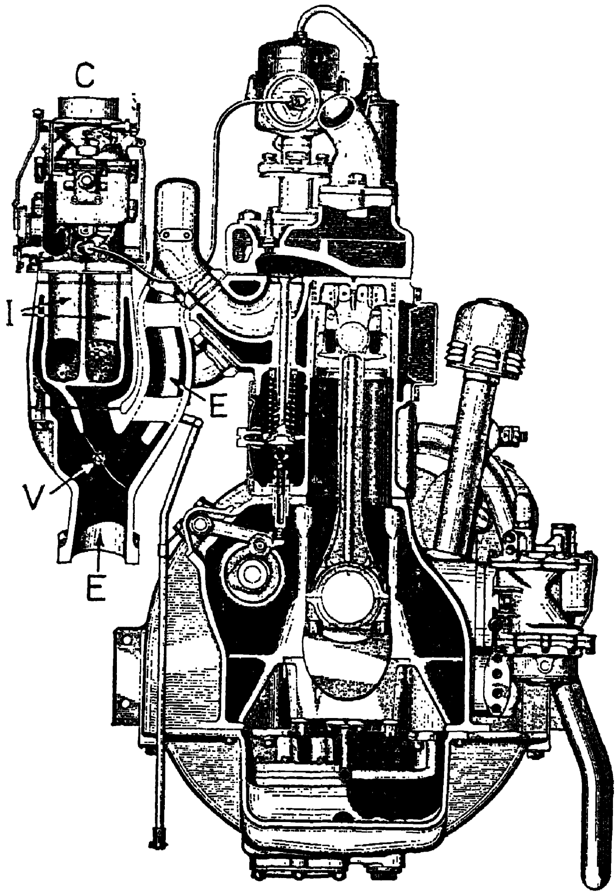


Fig. 94.—The Packard Engine, showing Carburettor Unit on left. C, Down-draught Carburettor. I, Dual Inlet Manifold. E, Exhaust Gas Manifold. V, Exhaust Gas Control Throttle for Carburettor Heating.

Generally, the fuel consumptions of engines fitted with American carburettors are heavier than those of English models; there are, however, certain exceptions in the more recent models.

Exhaust Heated Mixing Chambers.—An interesting feature of certain more recent carburettors, such as those fitted to Cadillac, Buick and Hudson cars, is the arrangement for a variable heat control to the mixing chamber of the carburettor.

This usually takes the form of a throttle valve placed in the exhaust passage leading to the exhaust heated jacket around the mixing chamber. By altering the position of this valve the amount, or volume, of the exhaust gases passing into the mixing

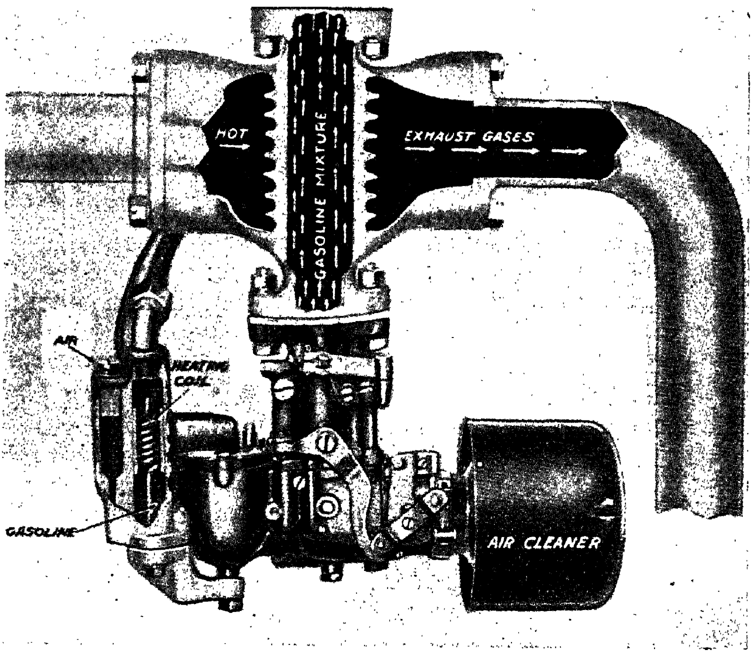


Fig. 95.—The Exhaust-heated Franklin Carburettor, showing Electric Heater for Starting and the Air-Cleaner.

chamber jacket can be varied. In the case of the Buick car this throttle is controlled by a lever on the dash-board (Fig. 93).

In certain model Hudson cars this throttle is connected, by suitable linkage,* to the accelerator pedal,

*Vide Fig. 108.

or carburettor throttle mechanism in such a way that the greatest amount of heat is deflected to the jacket when the throttle is only partly open—as when idling or at low speeds. As the carburettor throttle is opened further for higher speeds the exhaust throttle is closed progressively.

Apart from this automatic action, there are three alternative, or zero, settings of the exhaust throttle to suit extreme and mean climatic conditions. These settings are marked "Warm," "Medium," and "Cool," respectively. The former setting opens the exhaust throttle in its initial or starting position, so as to allow more of the exhaust to enter the jacket when the carburettor throttle is nearly closed. This setting is used for cold weather conditions. The "Cool" condition applies to cars used under hot climatic conditions, and corresponds to the minimum exhaust heating of the mixing chamber.

The Bendix-Stromberg Carburettor.—This design of down-draught carburettor is fitted to American and also to certain British makes of car.* It is made with a die-cast metal main body and cast-iron throttle-valve body; the latter is a safeguard against warping under heat influence.

The later models have larger float-chambers and floats than their earlier ones, whilst the economiser valve and acceleration pump are now two separate units each capable of being adjusted independently of the other.

The Bendix-Stromberg carburettor is shown in part section in Fig. 96.

The float chamber cover (20) is detachable, and is held in place by three small screws. The main body is split horizontally at (1), the joint being held by two screws. It is necessary to split the body here in order to change the venturi tube (21).

The Stromberg systems of mixture correction by air bleed and the idle lay-out are retained together with the economiser valve, ensuring the delivery of lean economical mixtures at part-throttle running.

* Messrs. Bendix Ltd., Birmingham.

The operation of the carburettor will be understood on reference to the illustration. Fuel flows into the float chamber *via* the needle valve (8), and the level is maintained at the required height by the float (5).

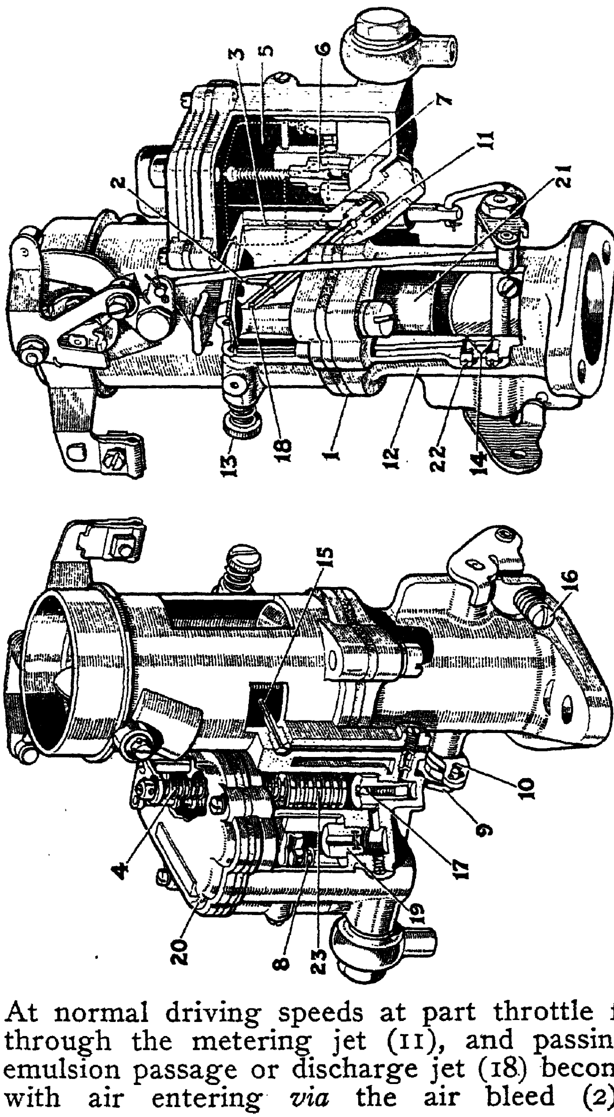


Fig. 96.—The Bendix-Stromberg Carburettor.

1, Main Body Gasket. 2, Air Bleed. 3, Idle Tube. 4, Pump Spring. 5, Float. 6, Economiser Valve. 7, By-pass Jet. 8, Needle Valve. 9, Pump Link. 10, Holes for Pump Lever. 11, Metering Jet. 12, Throttle-valve Body. 13, Idling Air Screw. 14, Idle-discharge Holes. 15, Pump-discharge Jet. 16, Throttle-stop Screw. 17, Delivery-ball Valve. 18, Main discharge Jet. 19, Check-disc Valve. 20, Float-chamber Cover. 21, Venturi Tube. 22, Plugs. 23, Pump Piston.

At normal driving speeds at part throttle fuel flows through the metering jet (11), and passing up the emulsion passage or discharge jet (18) becomes mixed with air entering *via* the air bleed (2), and is

discharged into the air stream at (18). Since full throttle demands a richer mixture for power, the action of opening the throttle fully forces open the economiser valve (6), when the required amount of extra fuel is permitted to meter through the by-pass jet (7), thus enriching the mixture to the desired degree.

The fuel for idling and small throttle openings is taken from the delivery side of the main metering jet, and is metered by the restriction at the base of the idle tube (3). After being drawn past the restriction, the fuel passes up the idle tube, along the horizontal passage, when it meets air admitted by the idling air screw (13), and thence down to the two idle-discharge holes in the throttle-valve body (12).

The prompt and rapid acceleration of the Bendix-Stromberg carburettor is made possible by the action of the accelerating pump, which delivers a small and governed quantity of fuel into the air stream when the throttle is suddenly opened. When the throttle is closed the pump piston is drawn up and the cylinder is charged with fuel through the check-disc valve (19). On the throttle being opened suddenly the piston descends and compresses the fuel in the cylinder, closing the check valve (19) and opening the delivery-ball valve (17), through which the fuel is forced on its way to discharge via the pump-discharge jet (15).

Easy starting is ensured by the Bendix-Stromberg automatic "Varie Flow" strangler valve, which, when the strangler knob is pushed in slightly after the initial start, opens and closes in accordance to the engine suction, thus putting only the required degree of depression upon the jets to ensure the correct mixture, and rendering over-strangling or choking impossible. A still further safeguard in this respect is the incorporation of an auxiliary disc-relief valve in the strangler valve itself, which operates in the event of the engine being run with the strangler knob right out.

Additional refinement in the form of the Bendix-Stromberg "Fast Idle" may be incorporated, which obviates the necessity for hand or foot control of the throttle when starting. This operates by mechanical

linkage between the strangler mechanism and the throttle, so that when the strangler knob is pulled out for starting the throttle is automatically held open sufficiently to give an engine speed that will not stall at low temperatures. The "Fast Idle" functions over the whole range of the strangler movement, and only goes out of action when the strangler valve is open in the running position.

These carburettors are also designed for use with the Bendix-Stromberg automatic thermostatically controlled device governing the mixture strength over the cold-starting and warming-up period, as described in Chapter IV.

Adjusting the Bendix-Stromberg Carburettor.—(1) *Idling and Low Speeds.*—This must be carried out with the engine well warmed up. With the hand throttle in the closed position, adjust the throttle-stop screw (16) to give the desired engine speed. The idling air screw (13) controls the strength of the idling mixture, and the screw should be turned in and out until the position is found when the engine rhythm is most regular. Screwing *in* gives a *richer* mixture, and screwing *out* a *weaker* one. If a satisfactory adjustment cannot be obtained with any setting of the air screw, the idle-discharge holes (14) should be inspected by removing the plugs (22). The idle tube (3) may be removed for inspection by taking off the float chamber cover.

(2) *Part Throttle and High Speeds.*—The main metering jet should be of a size sufficient to pass the required amount of fuel for smooth running at speeds from about 15 m.p.h. up to 45-50 m.p.h., at which point the economiser valve will open. The size of the economiser or by-pass jet (7) is governed by the amount of extra fuel required to bring the mixture up to full throttle strength and is usually about 40 per cent. smaller in diameter than the metering jet.

(3) *Acceleration Pump Adjustment.*—The quantity of fuel delivered by the pump is controlled by the size of the pump-discharge jet (15), and the *duration* of the charge by the spring (4).

The stroke of the pump may be altered by changing the link (9) from one of the two holes (10) to another, the hole nearest the throttle spindle giving the less discharge and *vice versa.* Normally the link is in the

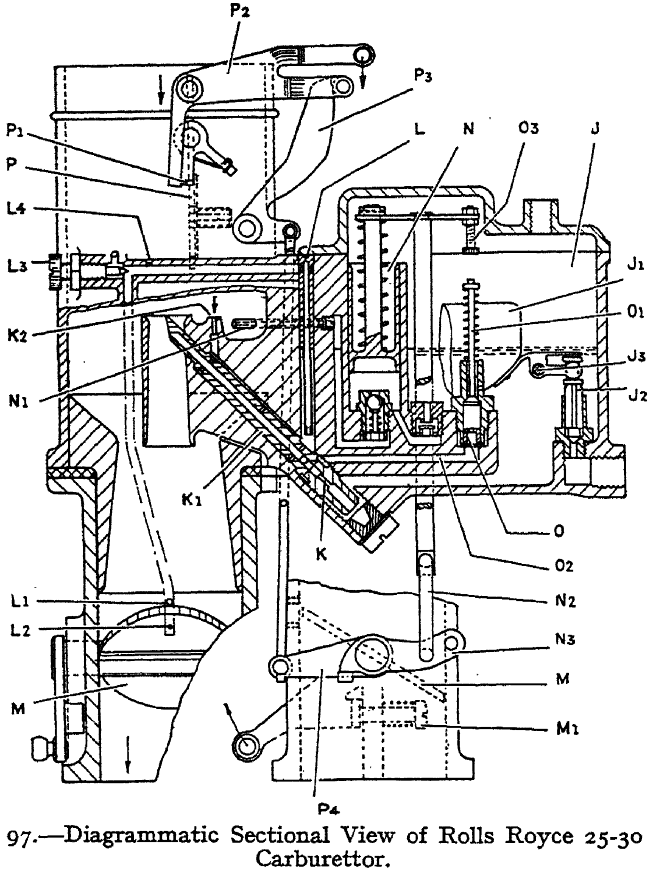


Fig. 97.—Diagrammatic Sectional View of Rolls Royce 25-30 h.p. Carburettor.

J, Float Chamber. J_1, Float. J_2, Needle Valve. J_3, Fulcrum Pin of Float. K, Main Metering Jet. K_1, Emulsion Jet. K_2, Main Air Bleed. L, Pilot or Slow-running Jet. L_1, L_2, Slow-running Discharge Holes. L_3, Slow-running Mixture Adjustment. L_4, Anti-syphonic Air Bleed. M, Throttle Valve. M_1, Throttle Stop Screw. N, Accelerator Pump Plunger. N_1, Pump Metering and Delivery Jet. N_2, Pump Coupling Link. N_3, Lever fixed on Throttle Spindle. O, Economiser Metering Jet. O_1, Economiser Valve. O_2, Fuel Passage from Economiser Jet. O_3, Tappet for Economiser Valve. P, Strangler Valve. P_1, Projection on Strangler Operating Lever. P_2, Strangler Control Lever. P_3, Cam Coupling Strangler Control to Throttle. P_4, Lever Free on Throttle Spindle.

farthest hole, which may be termed the winter setting. If the pump discharge appear excessive during the summer months, the link should be moved

into the second hole. It is inadvisable to attempt any other re-adjustment of the pump without first consulting the makers.

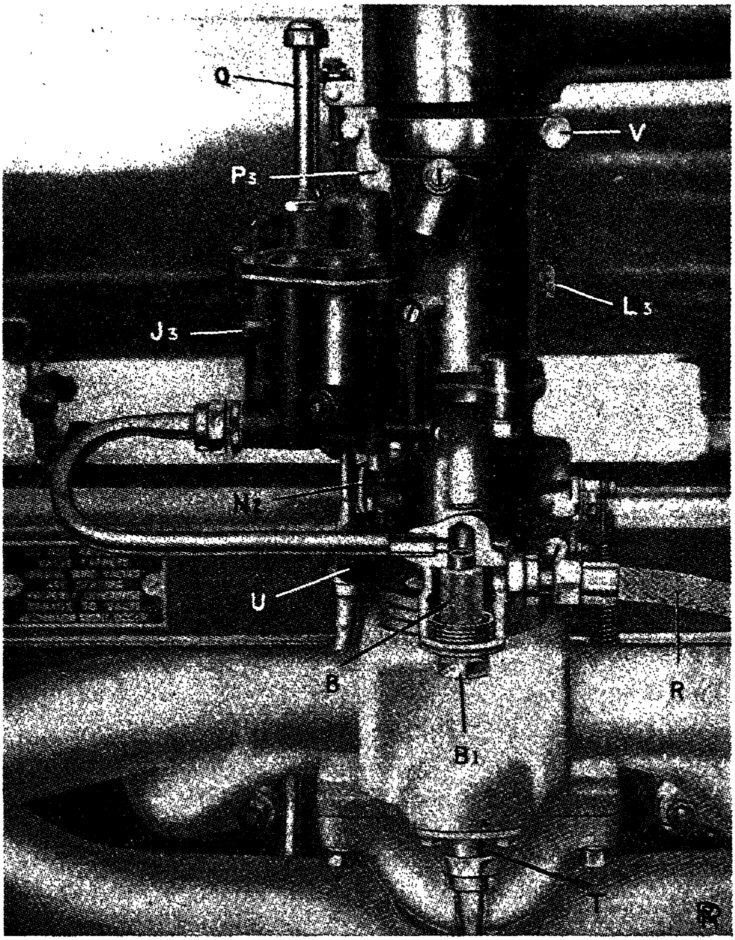


Fig. 98.—The Rolls Royce 25/30 H.P. Bendix-Stromberg Carburettor. B—Petrol filter. B_1—Filter cleaning union connection. J_3—Fulcrum pin for removing float. L_3—Idling mixture adjustment screw. N_2—Pump coupling link. P_3—Cam coupling strangler control to throttle. Q—Float chamber vent. R—Flexible petrol pipe to filter and carburettor. T—Fuel drain with engine-suction seated non-return valve. U—Tray below carburettor to trap any leakage fuel. V—Clamping bolt for air-cleaner above.

(4) *Float Level.*—The standard setting of the fuel level in the float chamber is $\frac{9}{16}$ in. below the top face of the float chamber, and is easily examined by removing the float-chamber cover when the height of the fuel level may be measured. It should be unnecessary to make any alteration unless special fuels are being used or the carburettor has been handled roughly. When necessary, the level can be corrected by carefully bending the float arm where it meets the float. Bending the float up will raise the level, and vice versa.

The Rolls Royce Model.—The later model Rolls Royce 25/30 and 40/50 engines employ the Bendix-Stromberg carburettors of the down-draught pattern, with the usual economiser jet, mechanically-operated accelerator pump and an extra jet coupled with the throttle control, for acceleration and for full power running conditions, respectively.

A sectional view of the 25/30 carburettor—which is of the single-choke tube pattern, is given in Fig. 97. The 40/50 engine uses a dual carburettor, i.e., a single unit with dual choke tubes and mixture control devices.

Fig. 98 shows the Rolls Royce model carburettor, in position on the engine, and the petrol pipe and fuel filter; the principal items seen externally are lettered and described in the caption below the illustration.

The Ford Vee-Eight Carburettor.—The eight-cylinder Vee-type Ford engine has a dual pattern, single unit carburettor which is, in effect, equivalent to two separate carburettors, but with a common float chamber, float valve, choke valve and accelerating pump; the discharge from the latter is equally distributed between the two carburettor barrels. Each of the latter supplies four cylinders of the engine; thus one supplies cylinders 1, 4, 6 and 7, and the other, cylinders 2, 3, 5 and 8.*

The following description refers to one carburettor barrel; the operation of the other barrel, however, is identical:—

* See Fig. 89.

Idling Operation.—Petrol from the float chamber, passes through the main jet A, Fig. 100, and is drawn upwards through the idling jet C past the air inlet passage B, Fig. 101.

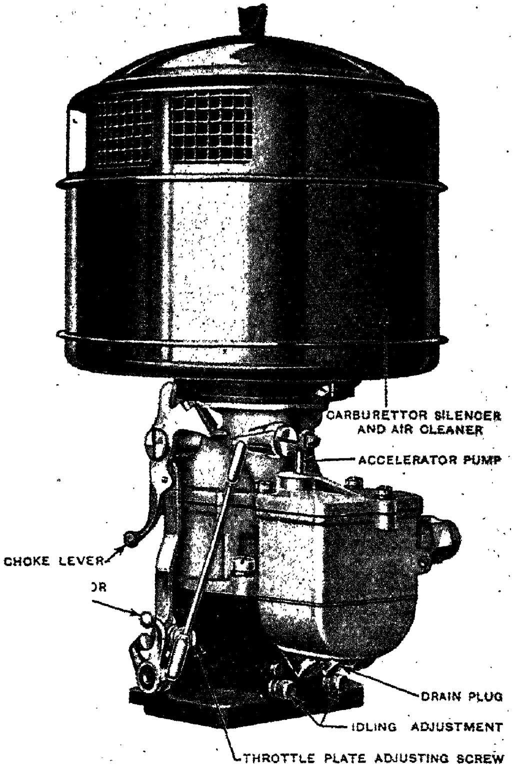


Fig. 99.—The Ford Vee-Eight Carburettor.

This air inlet passage is connected to the carburettor choke tube, and air entering at this point mixes with the petrol stream drawn from the main jet A, *via* the idling jet C. Fig. 101.

This mixture of petrol and air then travels downwards, as indicated by the arrows in Fig. 101, and is discharged into the manifold through the idling discharge holes.

In normal operation with the throttle plate closed to the correct position for idling, as indicated by the dotted lines in Fig. 101 (that is, to an engine speed equivalent to 5 to 7 m.p.h.), the lower idling discharge hole only is subjected to the induction manifold vacuum.

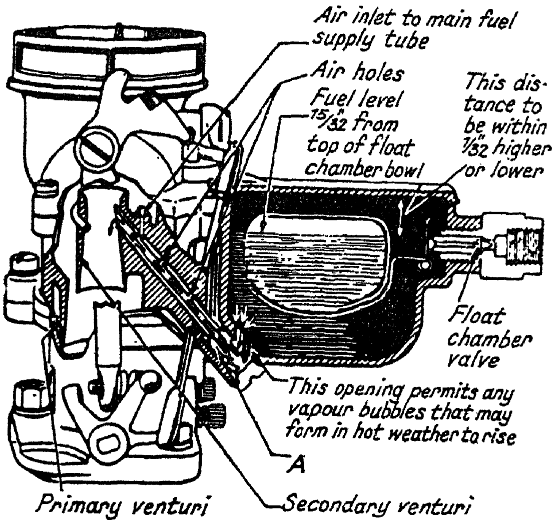


Fig. 100.—Ford Vee-Eight Carburettor.

The upper idling discharge hole being above the throttle plate, is not affected and does not discharge any fuel.

The lower idling discharge hole is provided with a needle adjustment controlling the quantity of mixture supplied.

The carburettor is also provided with an unbalanced choke valve in which an air bleed valve is incorporated as shown in Fig. 101.

When the choke button on the dash is operated, the choke valve is closed and the throttle valve is automatically opened to the correct position for starting.

For this reason *the throttle button should not be pulled out when starting.*

Fig. 101 shows the position of the throttle plate when the carburettor is choked and, when in this position, the throttle plate is directly opposite the upper idling discharge hole.

This position allows the stream of air passing the throttle plate to draw a fuel and air mixture from both upper and lower idling discharge holes, whereas in the normal, unchoked idling position of the plate as shown by the dotted lines in Fig. 91, the mixture is drawn from the lower discharge hole only.

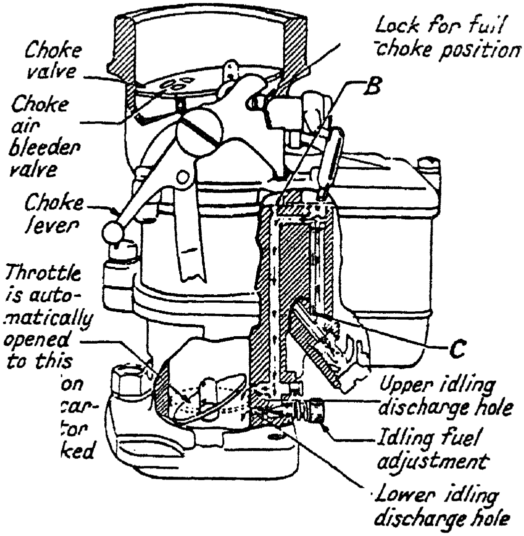


Fig. 101.—Ford Vee-Eight Carburettor.

When the carburettor is fully choked, in addition to the mixture supplied from the two idling discharge holes, the main discharge nozzle also supplies fuel to the engine, as shown by the arrows in Fig. 100.

When the carburettor is not choked, the entire fuel supply to the engine for all speeds up to 25 m.p.h. is supplied from the idling discharge holes Fig. 101.

The choke valve is pivoted off centre so that at any position other than fully shut, the flow of air through the carburettor has a tendency to keep the choke valve open so that the possibility of flooding the engine is minimised.

This does not mean that the car may be operated continuously with the choke button partly pulled out, as this will result in an over rich mixture being supplied to the engine with the consequent heavy petrol consumption and crankcase dilution.

In full choke position, the choke valve is held firmly in place by a stop to prevent the air stream from forcing it open.

To supply the necessary air to the carburettor when fully choked, a spring controlled air bleed valve is incorporated in the choke valve, Fig. 101.

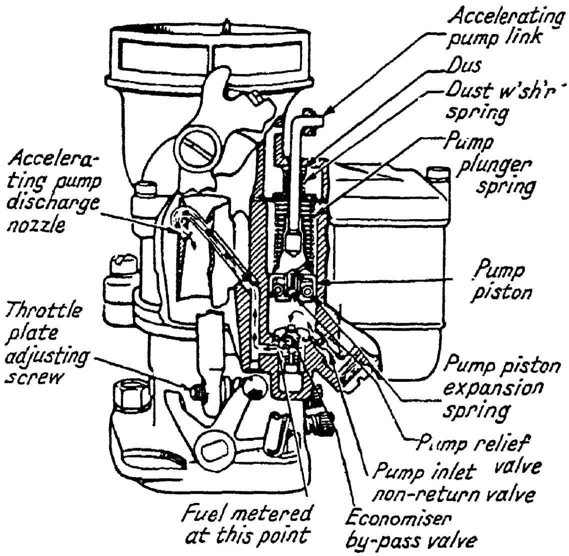


Fig. 102.—Ford Vee-Eight Carburettor.

The operation of this air bleed valve creates a distinctive noise which should attract attention to the carburettor being fully choked; this noise continuing until the choke button is pushed either all the way in, or to a part choke position.

Main Operation.—Above a speed of approximately 25 m.p.h. the main fuel discharge nozzle supplies all the fuel up to approximately 75 m.p.h. Above this speed, extra fuel is supplied from the economiser by-pass valve Fig. 102.

The fuel from the float chamber passes through the main jet A and is drawn up the main discharge tube to the secondary venturi as shown in Fig. 100.

As the fuel is drawn from the main discharge tube, the idling fuel supply passages are emptied into the main supply.

Air entering at the opening in the main choke tube, as indicated in Fig. 100, completely surrounds the main fuel supply tube, and is led to the fuel stream through several small holes in the side of the main supply tube, Fig. 100.

The primary venturi, Fig. 100, increases the speed of the air flow; the secondary venturi being positioned so that the intake end is above the restriction of the primary venturi, and the discharge end is below the primary venturi restriction, gives a still greater velocity to the air stream in the secondary venturi.

Accelerating Pump.—The accelerating pump, Fig. 102, is provided to slightly enrich the fuel mixture for rapid acceleration.

Movement of the hand or foot throttle control operates the accelerating pump which forces fuel drawn from the float chamber through the non-return valve, Fig. 102, down through the economiser by-pass valve which is provided with a calibrated orifice to permit a sufficient amount of extra fuel to be supplied for rapid acceleration without permitting flooding of the engine.

When the movement of the accelerating pump piston is too rapid to force all the fuel in the pump cylinder through the by-pass valve, the relief valve in the pump piston opens and permits escape of the surplus fuel to the float chamber.

The fuel from the by-pass valve is forced along the pump tube and is discharged from the nozzle that projects into the secondary venturi, Fig 102.

When the throttle is fully opened, the accelerating pump having moved to the bottom of its stroke, mechanically opens the valve in the economiser by-pass permitting the economiser to act as a power jet.

This occurs at a speed of approximately 75 m.p.h in top gear.

Float Chamber Fuel Level.—As indicated in Fig. 100, the correct level for the fuel in the float chamber of these carburettors is 15/32 inch from the top of the float chamber bowl.

This level is extremely important and should not vary more than 1/32 inch higher or lower.

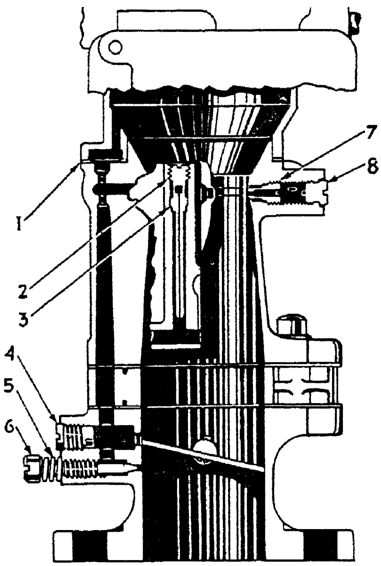


Fig. 103.—Front Sectional View of Chrysler Carburettor.
1, Air Horn Gasket. 2, Idle Orifice Plug. 3, Idle Orifice Tube. 4, Idle Hole Plug. 5, Idle Adjustment Screw Spring. 6, Idle Adjustment Screw (and Valve). 7, Pump Jet. 8, Pump Jet Plug.

Adjustments.—Allow the engine to warm up, and make sure there are no air leaks at the intake manifold, wind-shield wiper, and distributor vacuum brake connections, and set the idling speed of the engine by means of the throttle adjusting screw, Fig. 102, to a speed equivalent to approximately 5 m.p.h. in top gear.

Adjust the idling speed on one side of the carburettor by means of one of the idling adjustment screws, Fig. 101, by turning the screw slowly in until the engine begins to lag or run irregularly, then slowly turn the screw out until the engine begins to "roll".

The adjustment screw should now be turned in just enough to permit the engine to run smoothly.

This adjusts the mixture for one side of the carburettor; the same procedure being followed for the other side.

The approximate correct setting for the idling adjustment valves is $\frac{5}{8}$ to $\frac{3}{4}$ of a turn open.

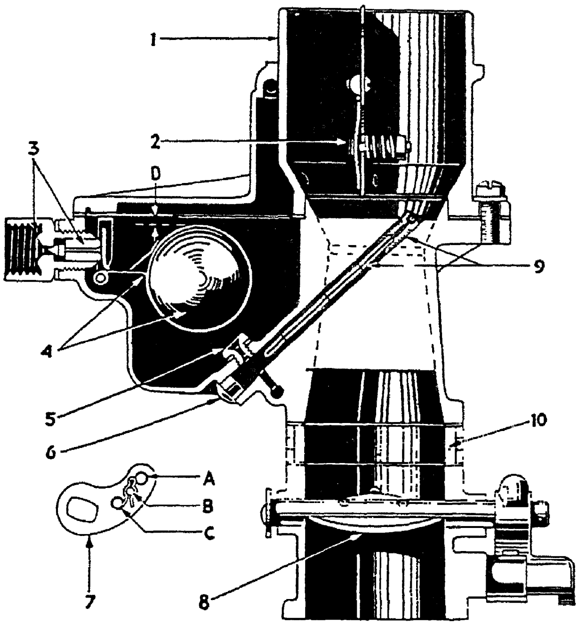


Fig. 104.—Side Sectional View of Chrysler Carburettor.

A, Accelerating Pump Winter Setting (outer hole, long stroke). B, Accelerating Pump Intermediate Setting (centre hole). C, Accelerating Pump Summer Setting (inner hole, short stroke). D, $\frac{1}{16}$" (1.58 mm.). 1, Air Horn Assembly. 2, Choke Valve Assembly, 3, Float Needle and Seat Assembly. 4, Float and Lever Assembly. 5, Main metering screw. 6, Plug. 7, Accelerating Pump Lever. 8, Throttle Valve. 9, Main Vent Tube and Plug Assembly. 10, Body Flange Spacer.

It may be necessary after making these adjustments to again reduce the engine speed down to approximately 5 m.p.h. by means of the throttle plate adjusting screw.

The Chrysler Carburettor.—One pattern of the Chrysler carburettor, shown in Figs. 104 and 105, is of the plain tube down-draught pattern, having fixed petrol jets to cover the whole speed range, except the

idling speed. For slow-running or idling an adjustment is provided, but this is ineffective when the throttle is opened.

The mixture strength is enrichened by turning the adjusting screw in an anti-clockwise direction.

The carburettor throttle is connected, mechanically, to the air choke, so that if the latter is more than half "on", the throttle will open slightly to prevent stalling when warming up a cold engine.

An accelerating pump is fitted to this carburettor. It is arranged to give three different rates of discharge, depending on climatic conditions. For normal operation the pump link is connected to the middle hole in the pump lever. For very cold weather conditions, to the outside hole, and for hot weather to the inside hole.

The various metering screws and jets have accurately drilled holes of pre-determined size, and for this reason should only be cleared by a compressed air jet; a wire should never be used.

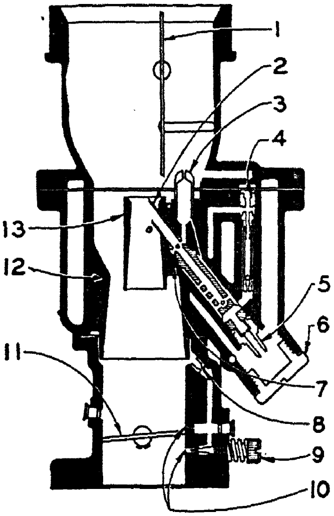
An automatic choke is provided on some models for the starting and warming-up periods. A felt filter type of air cleaner is fitted to all models.

Stromberg Carburettor.—A typical modern design of Stromberg carburettor is shown in Fig. 105. This model embodies idling jet, main metering jet, main and auxiliary venturi, acceleration pump, automatic thermostatic controlled air choke, etc.; it belongs to the down-draught class, the particular model shown being fitted to the Packard 8-cylinder engine.

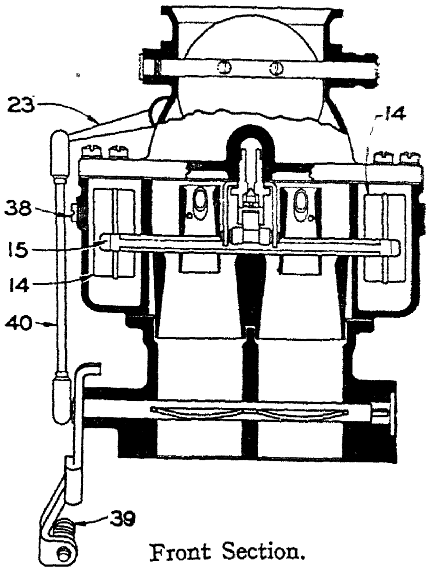
The Duplex down-draught Stromberg Model "AA-1" carburettor, fitted to certain model Buick cars, is the one illustrated in Fig. 105.

This carburettor is of special interest since it is similar in some respects to the modern aircraft models, having, for example, the aero type of float chamber referred to on page 46.

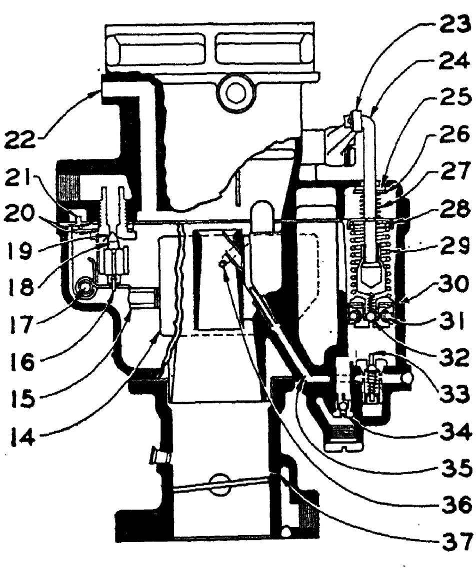
The fuel chamber, in this case, completely surrounds the body, so that the proper level of the fuel is always maintained, irrespective of the tilting of the engine; baffles are also provided to prevent fuel surge.



Side Section.



Front Section.



1, Choke Valve. 2, Main Discharge Jet. 3, High Speed Bleeder. 4, Idle Tube. 5, Main Metering Jet. 6, Main Discharge Jet Plug. 7, Main Discharge Jet Gasket. 8, Idle Air Bleeder. 9, Idle Needle Valve. 10, Idle Discharge Holes. 11, Throttle Valve. 12, Primary Venturi. 13, Auxiliary Venturi. 14, Float. 15, Float Lever. 16, Float Needle Valve Clip. 17, Float Fulcrum Pin. 18, Float Needle Valve. 19, Float Needle Valve Seat. 20, Float Hanger Gaskets. 21, Float Hanger. 22, Float Chamber Vent. 23, Pump Fulcrum Arm. 24, Pump Piston Link. 25, Felt Dust Washer. 26, Retainer Washer. 27, Dust Washer Spring. 28, Spring Retainer Washer. 29, Pump Duration Spring. 30, Pump Piston. 31, Pump Expansion Spring. 32, Pump Relief Valve. 33, Economiser By-Pass Valve. 34, Pump Inlet Check Valve. 35, Pump Discharge Channel. 36, Pump Discharge Nozzle. 37, Spark Control Hole. 38, Fuel Level Sight Plug. 39, Throttle Stop Screw. 40, Pump Rod.

Part Side Section.

Fig. 105.—The Stromberg Carburettor as fitted to Buick Cars.

The float needle valve is hooked to the float lever so as always to give positive action. A removable plate for checking the level of the fuel in the float chamber is another feature.

The carburettor is in reality two separate carburettors built into one. There is a set of venturi tubes, a main metering jet, an idle-running system with an adjustable needle, throttle valve and an acceleration pump discharge nozzle for each of the two outlet barrels. The single float chamber, however, feeds both barrels, but there is only one air inlet.

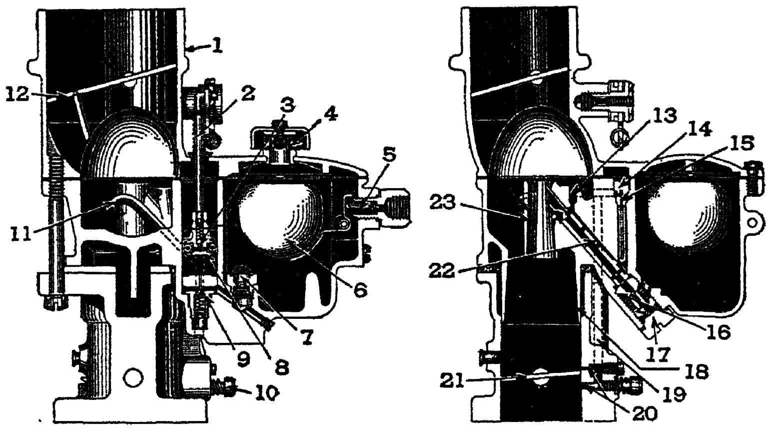


Fig. 106.—Schematic View Stromberg EE-23 Carburettor.

1, Air Horn. 2, Pump Piston Link. 3, Pump Relief Valve. 4, Bowl Vent. 5, Float Needle. 6, Float. 7, Pump Check Valve. 8, Pump Piston. 9, Economiser Valve. 10, Idle Adjustment. 11, Pump Nozzle. 12, Choke Valve. 13, High Speed Bleeder. 14, Idle Tube Bleed. 15, Idle Tube. 16, Main Metering Jet. 17, Metering Jet Cap. 18, Main Venturi. 19, Idle Passage. 20, Idle Discharge Ports. 21, Throttle Valve. 22, Main Discharge Jet. 23, Auxiliary Venturi.

The idling system supplies all the fuel at idling speeds and also on part throttle up to about 20 m.p.h. From the latter speed to 75 m.p.h., part throttle, all of the fuel is supplied through the main metering system. The additional fuel for speeds above 75 m.p.h., and on all wide open throttle operations, is supplied through the economiser valve.

In regard to the *main metering system*, fuel enters the carburettor at the petrol inlet through the valve (18) and (19), and into the float bowl, where it is maintained at constant level by the float (14).

Air enters the carburettor through the air inlet, and places suction on the main discharge jet (2) or idle discharge holes (10), depending on the amount of throttle opening. The main metering jets (5) are of the fixed type. They control the flow of gas during the intermediate or part throttle position up to approximately 75 m.p.h. From the metering jet the fuel passes into the main discharge jet (2) where it is mixed with air from the high speed bleeder (3), and flows into the carburettor barrel down to the intake manifold.

All jets of the fixed type are calibrated at the factory to supply the correct mixture for normal operating conditions, and should not be changed without special instructions from the factory.

For maximum power or high speed running a richer mixture is required than that necessary for normal throttle opening. For part throttle opening, fuel is supplied through the main metering jet to approximately 75 m.p.h. At this position economizer valve (33) is forced down by the accelerating pump piston, allowing fuel to flow through economizer valve and discharging through pump discharge nozzle (36). Fuel is supplied continuously through these passages with throttle wide open.

The carburettor is fitted with an automatic thermostatically-controlled air choke, which is adjustable to suit climatic conditions.

The Schebler Carburettor.—This American carburettor belongs to the "mechanical class" in which the opening of the throttle causes the jet needle to be moved outwards, by means of a special cam action; there is also an automatic spring-loaded air-valve, which opens at a certain engine speed. Referring to Fig. 107, showing one model formerly used, it will be seen that fuel outlet from the concentric float chamber (fitted with a cork float) is inclined, and is partially closed by means of the needle valve I. The latter is interconnected with the throttle by means of a cam, so that the needle is withdrawn at a predetermined rate as the throttle is opened. This cam can readily be varied in its contour, so as to include any desired relationship of jet area to throttle open-

ing. The cam adjustment is graduated for setting purposes. A low speed air adjusting valve L is provided. Movement of the lever Z from the lowest reading (1) to the highest (3) increases the fuel flow and thus enrichens the mixture. There is also a screw adjustment for the auxiliary air valve A, to

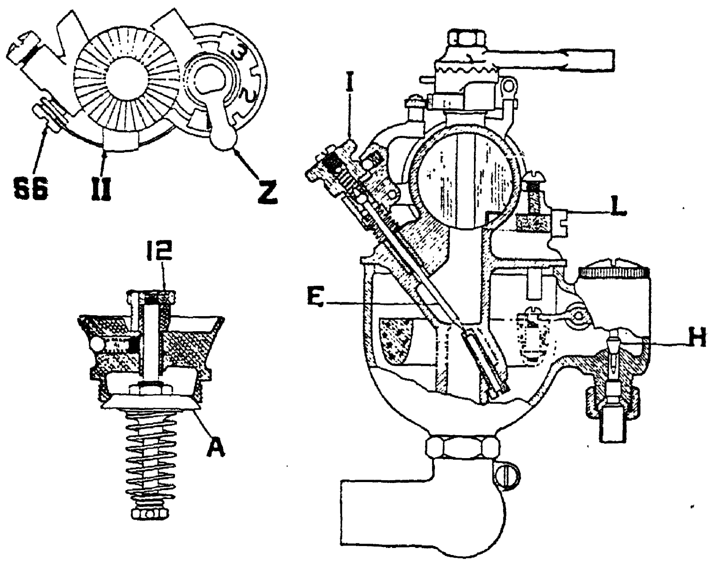


Fig. 107—The Schebler Carburettor.

vary the speed of opening, and the amount of the latter; the air valve can be locked in the closed position for starting purposes.

Various models of this carburettor with later improvements are made to suit different engine types, and fuels, for motor vehicles and motor-cycles.

The Marvel Carburettor.—The Marvel* carburettor has been fitted to Hudson, Essex and also to certain cars made by Messrs. General Motors Ltd.

The chief features of interest concerning this carburettor include an efficient starting device, acceleration pump and automatic exhaust heating to the mixture chamber.

* The Marvel Carburettor Co., Flint, Michigan, U.S.A.

There are two jets in the lower mixture chamber, of the fixed non-adjustable type. One is called the "low speed" jet, and is situated in a fixed air

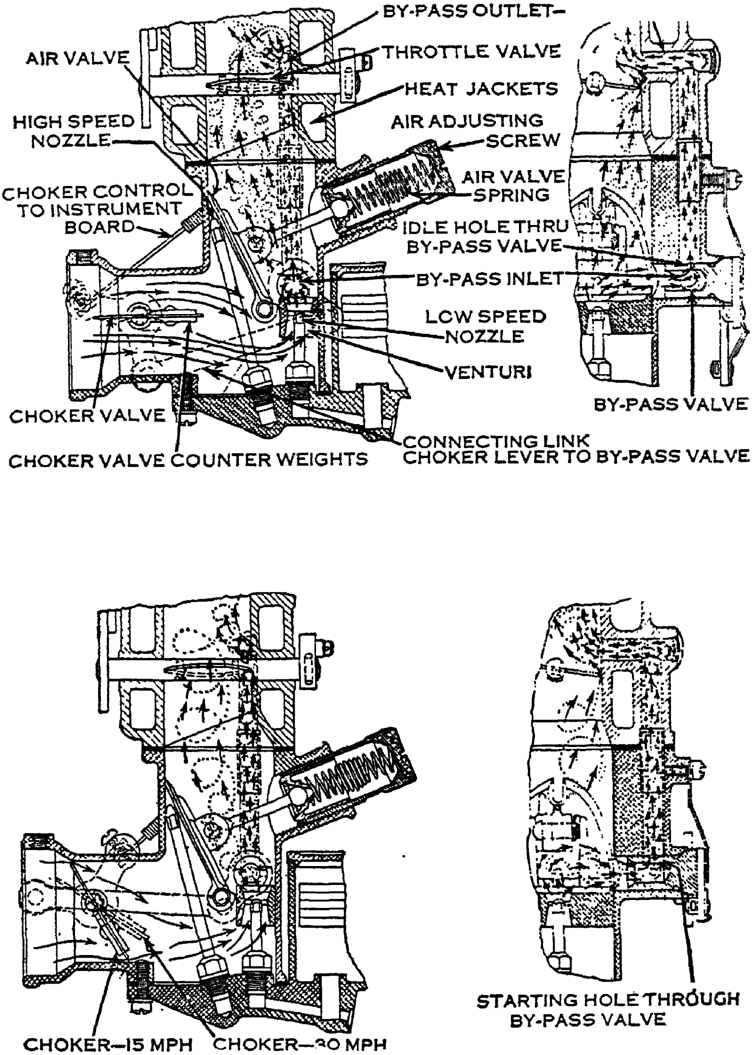


Fig. 108—The Marvel Carburettor.

opening, or choke; the other, "high speed" jet, is controlled by the automatic air valve (of the flat plate type) located underneath (Fig. 108).

An air screw is provided to regulate the pressure of the air valve spring; this constitutes the only mixture adjustment required.

A further control of the high speed jet is provided by the "economizer" which is a fuel metering valve operated by the carburettor throttle. This valve provides the maximum fuel feed to the "high speed" nozzle when the throttle is fully opened for high speeds, hill power and for quick "pick-up". During the ordinary driving ranges this valve controls the amount of fuel being used, thus providing all the economy possible. This valve is entirely automatic and requires no adjustment.

Built in with this valve also, is a throttle accelerating pump. Quick opening of the throttle provides a forced fuel charge from the high speed nozzle to assist in acceleration and quick get-away.

There is a seasonal control indicator for the accelerating charge on top of fuel bowl of carburettor. Adjacent to indicator the fuel bowl cover is marked for "Winter" and "Summer." These are used for cold and warm climatic conditions, respectively.

A choke button is provided on the instrument board for starting purposes. When pulled out it closes a butterfly choker valve in the air inlet of the carburettor, thus restricting the air supply; it is also inter-connected with the by-pass valve and opens a passage between the mixing chamber, just above the low-speed nozzle, and the intake manifold passage, just below the throttle. Due to the higher suction existing above the throttle, the over-rich starting mixture is, therefore, immediately drawn through the fixed opening in the by-pass valve, up past the throttle and into the intake manifold.

The Carter Carburettor.—This design of carburettor is fitted to a number of American car engines, of which the recent Chevrolet and certain models of Packard cars are typical instances.

It belongs to the down-draught class, and employs a triple diffusing type of choke, accelerating pump, variable metering jet, and a number of other interesting features.

The principle of the Carter carburettor as used on the Packard engine is shown in Fig. 109, the various numbered items being explained in the caption.

The carburettor employs five circuits as follows: (1) Float circuit. (2) Low speed or idling circuit (see Fig. 110). (3) High speed or power output circuit (see Fig. 110). (4) Pump accelerator circuit of the usual pattern and (5) Choke circuit for engine starting and warming purposes.

The Carter carburettor, as previously mentioned, employs three venturis, one located above and two below the level of the fuel in the float chamber. This triple venturi has the effect of increasing the suction on the first or primary venturi, causing the nozzle to start delivering fuel at very low air speeds. The nozzle enters the primary venturi at an angle, discharging upwardly against the air stream. This angle secures an even flow of correctly proportioned and finely atomized fuel.

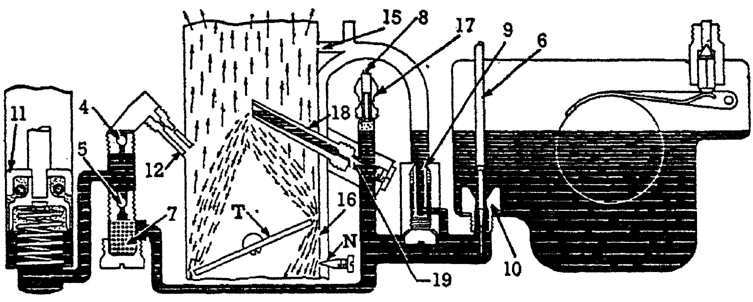


Fig. 109.—Diagrammatic Layout of Carter Carburettor.

4, Discharge Ball Valve. 5, Inlet Ball Valve. 6, Metering Rod. 7, Strainer. 8, Anti-percolator Valve Stem. 9, Low speed Jet. 10, Metering Rod Jet. 11, Pump Leather. 12, Pump Jet. 15, Idle Air Bleed. 16, Idle Port and Air Bleed. 17, Anti-percolator. Valve. 18, Main Jet Nozzle. 19, Nozzle Retainer Ring. N, Idle Port and Screw. T, Throttle Valve.

The fuel thus atomized in the primary venturi is kept centrally located in the air stream by the surrounding blanket of air passing into the second venturi, and this process is repeated by the air in the main venturi. By this means the fuel is carried to the cylinders in a more perfectly atomized condition. This insulated atomization results in increased smoothness of operation at both low and high speeds.

The mixture quality is controlled by a metering rod which operates within the metering rod jet, and is operated by the throttle lever. There are two steps of different diameters on this metering rod. The

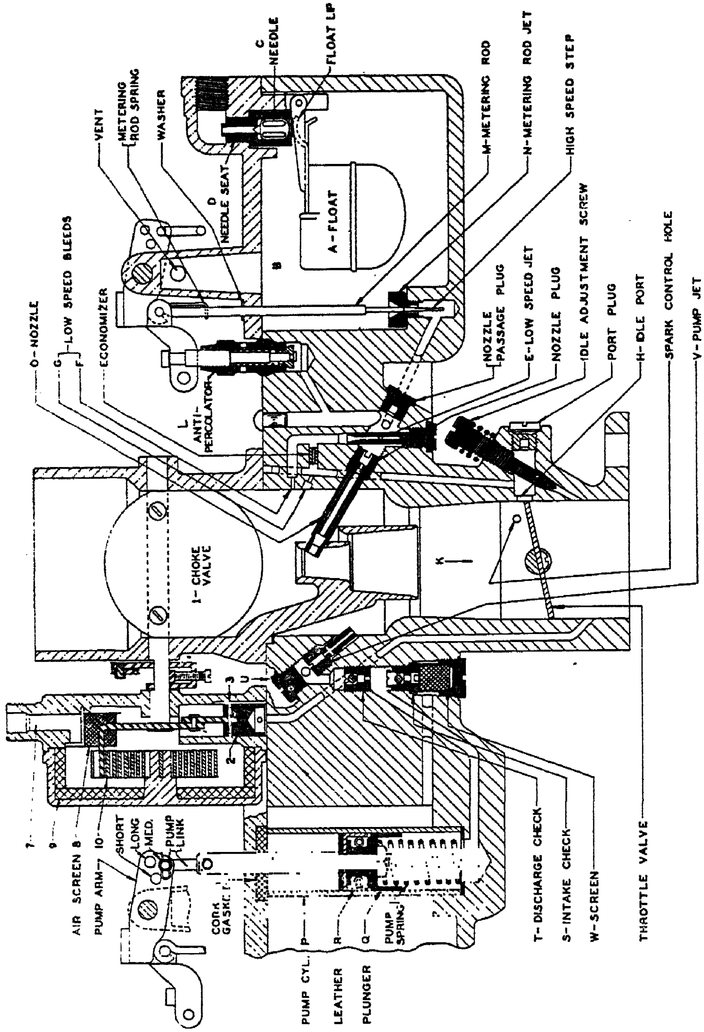


Fig. 110.—The Carter Carburettor with Thermostatic Air Choke and other refinements.

larger diameter, or economy step, controls the fuel flow to about seven-eighths throttle, when the smaller diameter, or power step, becomes effective, giving full

power for either high speed or hard low speed pulling. By this simple means both maximum power and greater economy can be had without changing the carburettor adjustment.

The choke consists of a butterfly valve, hinged at the centre, one half being spring controlled. When the engine is fully choked, the choke valve almost entirely cuts off the air supply, providing a rich mixture for easy starting. As soon as the engine fires, the spring-controlled half of the choke valve is sucked open and acts as an air valve in supplying the correct amount of air during the warming-up period. [The later model shown in Fig. 110 has a thermostatically-operated air choke.] This design prevents overloading of the manifold, and produces a smooth-running mixture with a cold motor.

The accelerating pump is of the pneumatic type, and consists of a cylinder with a plunger containing an air bell and two check valves, one on the inlet and one on the outlet side. The upward movement of the plunger, when the throttle is closed, draws a small metered quantity of fuel into the bottom of the cylinder. The slightest opening of the throttle causes an immediate discharge through a jet pointing downward into the main venturi.

Adjustments.—There are two adjustments, namely, one for the idling mixture and the other for idling speed. The float level is important, and should be maintained at the maker's recommended value, namely, $\frac{3}{8}$ in. from the underside of cover to the top of the float. The accelerating pump is provided with adjustments, giving three settings corresponding to short, medium and long strokes. The metering rods can be changed, if desired, to suit different climatic conditions or fuel grades.

The Cadillac Carburettor.—This interesting carburettor, which has been used on certain Cadillac models, possessing several unique features, was designed particularly to meet all of the requirements of the eight-cylinder engine to which it was fitted. The carburettor, which is located between the cylinder blocks, is of the float feed, single-jet

type. The float bowl, with its cork float, is directly below, and concentric with the mixing chamber. With this construction the float maintains the fuel at the proper level, no matter at what angle the car may be driven; there is thus no tendency to flood or impoverish the fuel supply in the jet.

The main air intake is an oblong-shaped opening in the side, from which the current of air is deflected to the bottom of the funnel-shaped strangle tube. The

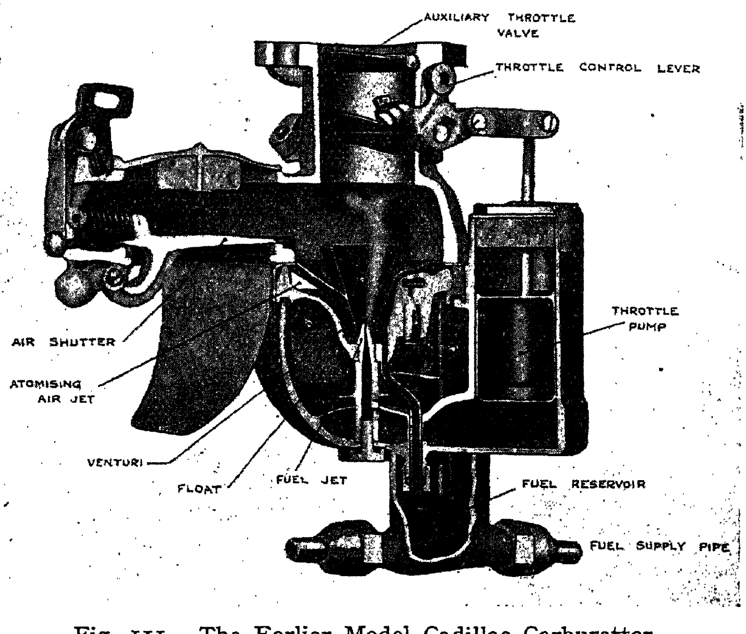


Fig. 111.—The Earlier Model Cadillac Carburettor.

venturi action of the latter tends thoroughly to atomize the fuel as it issues from the jet. The auxiliary air supply, by which the correct mixture is maintained automatically at different speeds and throttle openings, is controlled by a leather-seated swing valve, governed by an adjustable spring in tension. The mixture is further controlled by an automatic mixture "leaning" (or weakening) device. It is the operation of this device which prevents the enrichening of the mixture at high speeds.

Attached to the right hand end of the throttle shaft is a shutter which covers a slot in the side of the carburettor body whenever the carburettor is opened to the point where the mixture tends to become rich. When this slot is covered, a passage is formed from the mixing chamber to the carburettor bowl, resulting in a lowering of the atmospheric pressure to the latter, and causing less fuel to be fed through the spraying nozzle. An adjusting screw regulates the opening passage, and thereby the amount of fuel in the mixture, when the port is open. Enrichment of the mixture for starting is obtained by increasing the tension of the auxiliary air valve spring, a control lever being fitted for this purpose on the steering column.

A *throttle pump* is provided for giving a rich mixture for acceleration, which forces the necessary extra fuel through the spraying nozzle. When the throttle is opened slowly, this device has no effect on the amount of fuel fed into the mixing chamber, but when the accelerator pedal is rapidly applied the pump operates in the manner described. Besides the usual butterfly throttle valve, a second valve, under the spring tension, is placed just above the main throttle to prevent the "fluttering" of the latter when running slowly with the throttle wide open. The intake manifold is exhaust heated immediately above and below the carburettor, to assist in vaporizing low grade fuels.

The Stewart Carburettor.—This carburettor, once widely used, possesses several excellent features, and its claims for simple operation, slow running, starting and fuel economy have been verified by the writer. Fitted to an engine rated at over 20 H.P. (R.A.C.) a fuel consumption of over 30 m.p.g. has consistently been maintained in the case of a four-seater car. This carburettor belongs to the suction-controlled petrol-and-air supply type, there being no extra-air valve or pilot jet; the mixture strength is controllable from the dashboard by means of a variable needle valve mechanism for regulating the fuel supply.

Referring to the sectional view, Fig. 112, fuel enters the float chamber at A, through a fuel filter, or

strainer B, and passes to a dashpot chamber H through the passage G. It also passes through the holes I in the valve piston into the central space J, which surrounds the tapered fuel measuring (or metering) pin W. The metering valve has a piston L at its lower end which works in the dashpot chamber; this tends to steady the action of the metering valve during acceleration and at low speeds.

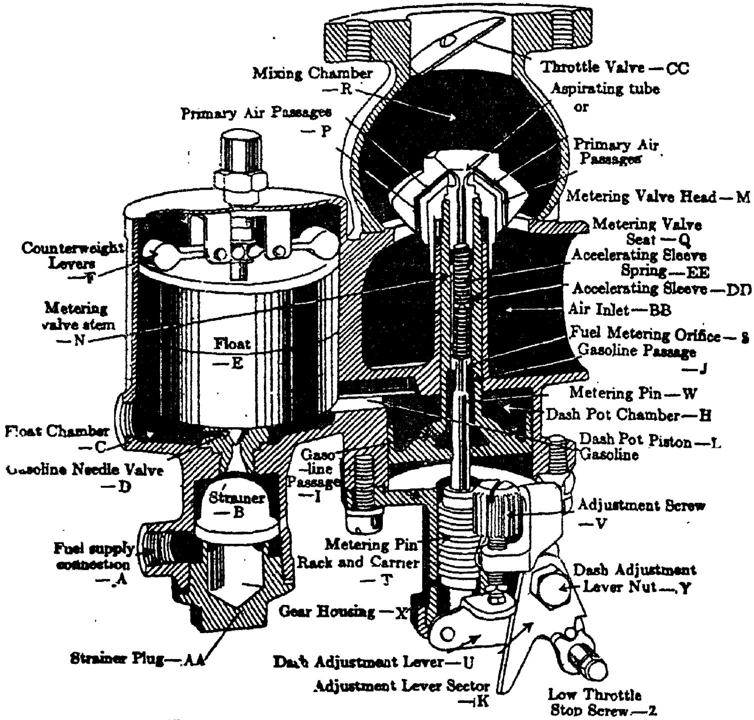


Fig. 112.—The Stewart Carburettor.

The metering valve consists of a conical shaped head M, stem N, and piston L. This is the only moving part in the carburettor. It slides up and down in its guide. The upper part of this valve contains a jet O and main air openings P. The stem carries an accelerating sleeve DD, and spring EE. When the engine is at rest the conical head of the metering valve seats in the carburettor body at Q. When running it floats in a higher position, thus

forming an annular shaped air opening between the conical head and its seat Q. The action of the carburettor is as follows: The suction created by the engine draws air into the mixing chamber R through the air openings P, and also draws a fine spray of fuel from the nozzle O into the mixing chamber. As the engine speed increases the metering valve lifts sufficiently to allow the main air supply to pass into the mixing chamber between the conical head M and the seat Q. Fuel is metered at S in an annular shaped orifice formed between the lower end of the accelerating sleeve DD and the tapered portion of the fixed metering pin W. The object of the accelerating sleeve is to increase the fuel flow by momentarily lifting upwards during rapid acceleration. As the engine speed is increased, the conical valve lifts more and more, thus increasing the air opening and also admitting more fuel, both in the required quantities.

Good atomization is given by the high velocity of the initial air passing through the hole P and around the nozzle O.

The Stewart carburettor is fitted with a device for altering the "fixed" setting of the metering pin W, and of thus varying the fuel supply or mixture strength independently of the automatic working of the carburettor. A small lever below the fuel needle W enables the latter to be moved up or down so as to decrease or increase, respectively, the mixture strength. In addition there is an adjustment screw stop V, which fixes the return position of the fuel adjusting lever; the latter is operated from the dashboard of the car, and is arranged to return to the setting given by the stop V. For starting and slow running the needle is moved downwards either by screwing V downwards, or opening the lever K so as to give a greater fuel area between the needle and its sleeve.

There is also a throttle stop for setting the slow running position of the throttle, and usually an exhaust heated sleeve and flexible metallic tubing main air supply, with a sliding sleeve on the latter for obtaining hot, warm or cold air for the carburettor

CHAPTER VI

MOTOR-CYCLE CARBURETTORS.

Motor-Cycle Carburettors.—Generally speaking, carburettors intended for motor-cycle use are smaller and more simple in construction than car types; they are also very accessible, and have few adjustments. Except in the case of certain recent types, much is left to the skill and discretion of the rider in the matter of mixture regulation under different running conditions. In many cases there was a fixed jet, a Bowden operated air slide and Bowden controlled sliding type throttle. The rider has then frequently to adjust the air supply to suit the speed and throttle opening; a good rider can undoubtedly get the best out of his engine, but has to be constantly adjusting the air lever. The automatic and semi-automatic type carburettors have come to the fore, however, and these are more suitable for the average rider. Usually the throttle controls also the jet and air opening, but there is an air slide which is closed for starting and slow running, and opened wide (and left there) for average running conditions. When running at lower speeds than normal, as on hills, with wide throttle openings, the air lever is closed a little. For racing purposes the single control straight through horizontal type carburettor is used; this gives the maximum charge possible to the cylinder. This type is automatic in action, but there is usually an auxiliary control to the jet for adjustment to atmospheric and acceleration conditions.

Carburettors for two-stroke engines are also made automatic or semi-automatic, but an auxiliary air control is fitted as the mixture adjustment is rather more delicate and the range less than in the case of four-stroke. A somewhat different design of car-

burettor is required for the "petroil" system of two-stroke lubrication, the jet being a little smaller, and the float rather heavier.

The Amac Carburettor.*—The Amac carburettor, shown in Fig. 113, works on the submerged jet principle and the jet functions simply as a metering orifice. The atomization is effected by a spraying

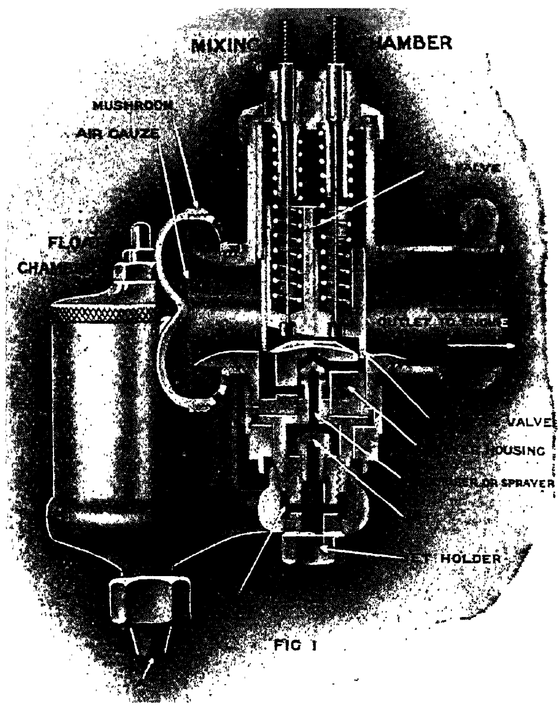


Fig. 113.—The Amac Carburettor.

cone which projects into the main choke-tube and is provided with four or six spraying holes. The jet is set to give maximum power at full throttle, and the mixture is controlled at intermediate openings by a

* This has now been superseded by the Amal Carburettor described later.

cylindrical piston valve which is cut away on the air intake side to allow for an increased area and consequently decreased depression over the sprayer. These valves are made with varying degrees of cut-away to enable the carburettor to be tuned to individual engines. On opening the throttle this cut-away passes above the bore and consequently decreases the ratio $\frac{\text{Air Intake Area}}{\text{Throttle Opening Area}}$ with the effect of progressively strengthening the mixture. A piston air valve slides inside the throttle valve and is controlled, as is the throttle, by Bowden cable. This is used to correct the mixture for changed temperature and road conditions, such as slow pulling on hills when the depression falls and renders the mixture over weak.

The float chamber is brass tube with stamped cover and base, and contains a cylindrical float which acts directly on an inverted cone valve in the case of the bottom feed and a needle in the top feed type.

The Brown and Barlow Motor-Cycle Carburettor.—This make of carburettor was widely used on motor-cycles for a long period, and in consequence was developed into a very reliable device. It has more recently been superseded by the Amal carburettor. Fig. 114 illustrates the ordinary type, known as the "Semi-Automatic Variable Jet Model". It is provided with two handlebar controls, namely, for the throttle and air, respectively. The throttle consists of a semi-cylindrical slide capable of moving up and down; it works with the semi-cylindrical air slide in a cylindrical barrel. The throttle carries also a long tapered needle valve which dips into the fuel jet, and as the throttle is opened (i.e., slid upwards) it raises the needle, thus increasing the jet area. The needle is compound in shape, namely, the first portion being parallel, and after a certain distance becomes tapered, the taper continuing to the end of the needle. The jet in which the needle slides is situated in a small choke-tube so that a certain amount of air is taken sufficient to atomize the issuing fuel. Fitted in the throttle, and completely enclosing the top of the

choke-tube is a cap* into which the fuel spray and air pass from the jet and choke. This cap is provided on one side with many holes of small diameter, through which the petrol and air have to pass; this ensures good atomization. The throttle is provided on the engine side with a small slot to give ease of control when running slowly. There is a small lever (seen on the side of the carburettor) for adjusting the easy starting pilot jet.

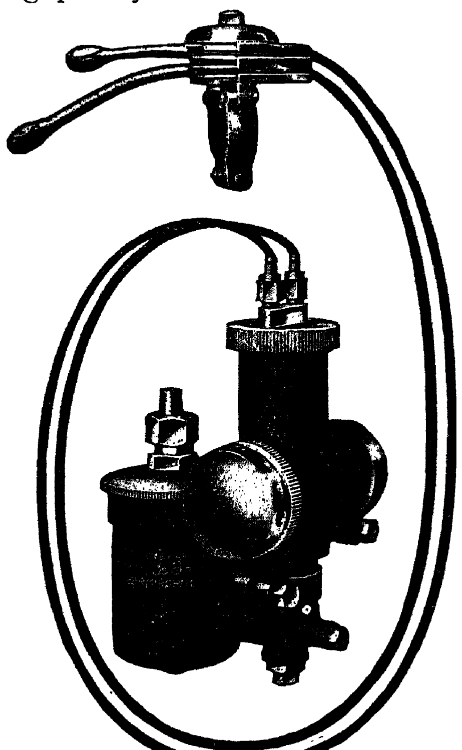


Fig. 114.—The B. and B. Variable Jet Two Lever Model.

Another popular carburettor made by the same manufacturers was the Single-Jet Semi-Automatic Model. With this, when the engine is started up the air lever is thrown open to a position determined by

* The later model had a fine gauze over the jet, serving the same purpose.

the size of jet used, and the carburettor then becomes automatic and can be driven on the throttle alone, except when working at full loads when the air lever can be partially closed to enrichen the mixture; this model contains the usual vaporizing cap, or gauze.

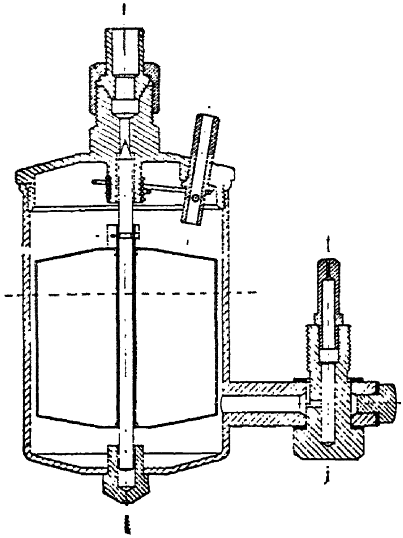


Fig. 115.—Float Chamber of B. and B Carburettor.

The Brown and Barlow Two-Stroke Type Carburettor.—This type was fitted with a single jet, which could readily be removed for changing purposes, and the usual B. and B. separate Bowden operated throttle and air slides. The jet was surrounded by a fixed size choke-tube covered by a vaporizing cap of gauze having a number of holes on its top and side through which the fuel and air from the jet and choke-tube, respectively, had to pass. A special domed dust-cap with ten, twelve, or fourteen air holes around it regulated the air intake and assisted the automatic action of the carburettor when the air lever was wide open and the proper jet was fitted. The carburettor could be supplied for use, either with petrol, or petroil*; a different float and jet are required in the latter case.

* The usual self-lubricating mixture of 8 to 12 per cent. lubricating oil in the petrol used on two-stroke engines. in place of a separate lubricating system.

The B. and B. Racing Type Carburettor.—Fig. 116 illustrates the straight through pattern racing car-

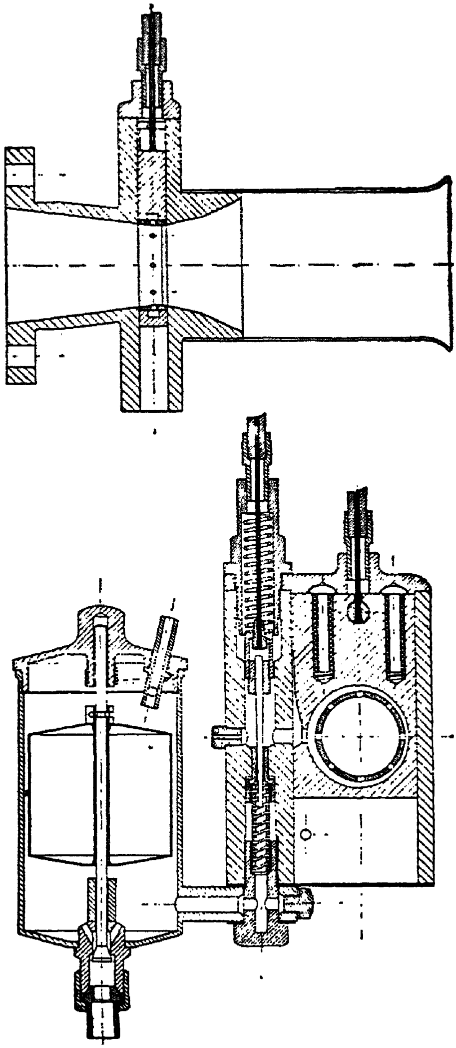


Fig. 116.—The B. and B. Racing Type Carburettor.

burettor, which was previously widely used, but has since been replaced by the Amal T.T. and Track Racing Carburettor. The special features of this carburet-

tor are its entirely automatic character, maximum volumetric efficiency (there being practically no loss of charge due to the carburettor), and the eight-jet throat-positioned fuel orifices. The composition of the mixture is governed by a cam-shaped groove on the side when the throttle is in any other position than full open. The initial or subsequent mixture adjustment is made by a separately controlled fuel needle valve, but the automatic action of the carburettor is in no way interfered with by this. The automatic side maintains uniform whatever mixture is "set" by the fuel needle valve, over the range of throttle openings.

Considerably larger inlet pipe diameters are usually employed than for touring practice. In the case of a 500-c.c. engine the maximum bore carburettor made, viz., $\frac{7}{8}$-in. diameter at the throat, will require in order to obtain its maximum results an inlet pipe of $1\frac{1}{4}$-in. internal bore.

The Amal Carburettor.—This popular motor-cycle carburettor is made in four models, viz., the single lever, double lever, horizontal single rod control and double rod control types; all work on the same principle, except in regard to the method of control.

The carburettor in question combines the best features of the Amac and Brown and Barlow models.

The mixture strength throughout the full range of movement of the throttle valve is maintained uniform by means of a suitable tapered needle adjustably attached to the throttle valve.

A metered jet is provided to regulate the maximum amount of fuel available at full throttle.

The idling system consists of a *pilot jet* and *by-pass*, provision for adjusting the mixture being provided by the horizontal knurled screw on the mixing chamber side; the throttle stop screw provides a definite throttle opening for idling when the control lever is closed.

Referring to Fig. 117, which shows the constructional arrangement, A is the carburettor body or mixing chamber, the upper part of which is fitted with throttle valve B, with taper needle C attached by needle clip.

Passing through the throttle valve is the air valve D, independently operated and serving the purpose of obstructing the main air passage for "starting" and "mixture regulation."

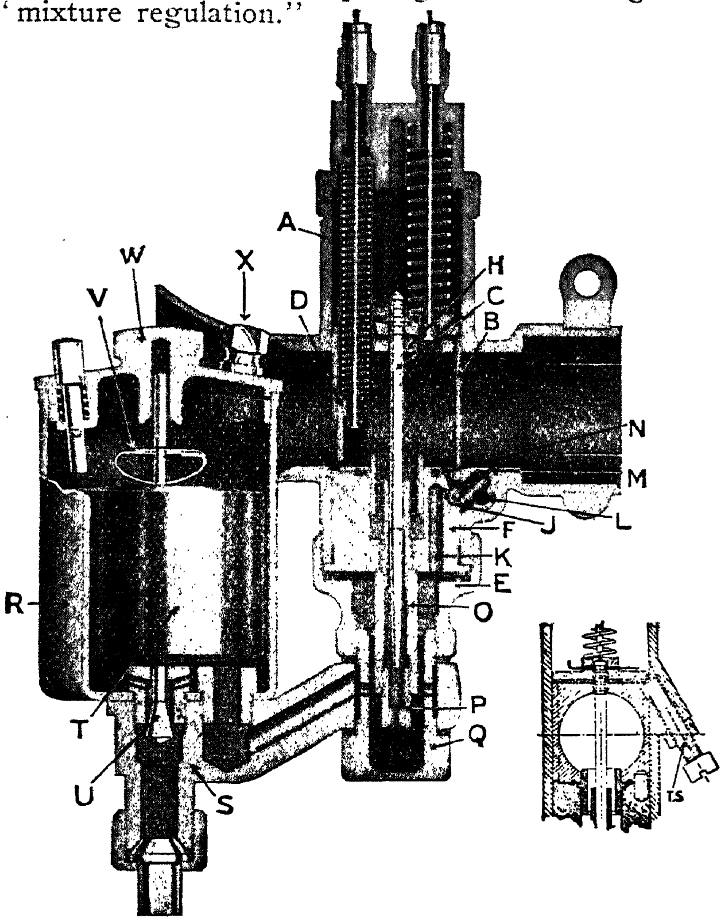


Fig. 117.—Sectional View of Amal Carburettor.

A—Carburettor Body or Mixing Chamber. B—Throttle Valve. C—Taper Needle and Clip. D—Air Valve. This passes through the Throttle Valve and is independently operated. It also serves the purpose of obstructing the main air passage for starting and mixture regulation. E—Union Nut. F—Jet Block—connected to Mixing Chamber by Union Nut E. Fibre washer interposed between, to ensure petrol-tight joint. H—Adaptor Body on upper part of Jet Block. J—Pilot Jet integral with Jet Block. K—Passage to Pilot Jet. L—Adjustable Pilot Air Inlet. M—Pilot Outlet. N—By-pass. O—Needle Jet screwed to underside of Jet Block. P—Main Jet. Q—Jet Plug bolting Mixing Chamber and Float Chamber together. When this plug is removed, both Jets can be dismantled. R—Float Chamber. This can be supplied with either top or bottom feed. S—Float Chamber Platform. T—Float. TS—Throttle Stop. U—Needle Valve. V—Needle Valve Clip. W—Float Chamber Cover. X—Float Chamber Cover Lock Screw.

Attached to the underside of the mixing chamber, by the union nut E, is the jet block F, and interposed between them a fibre washer to ensure a petrol-tight joint.

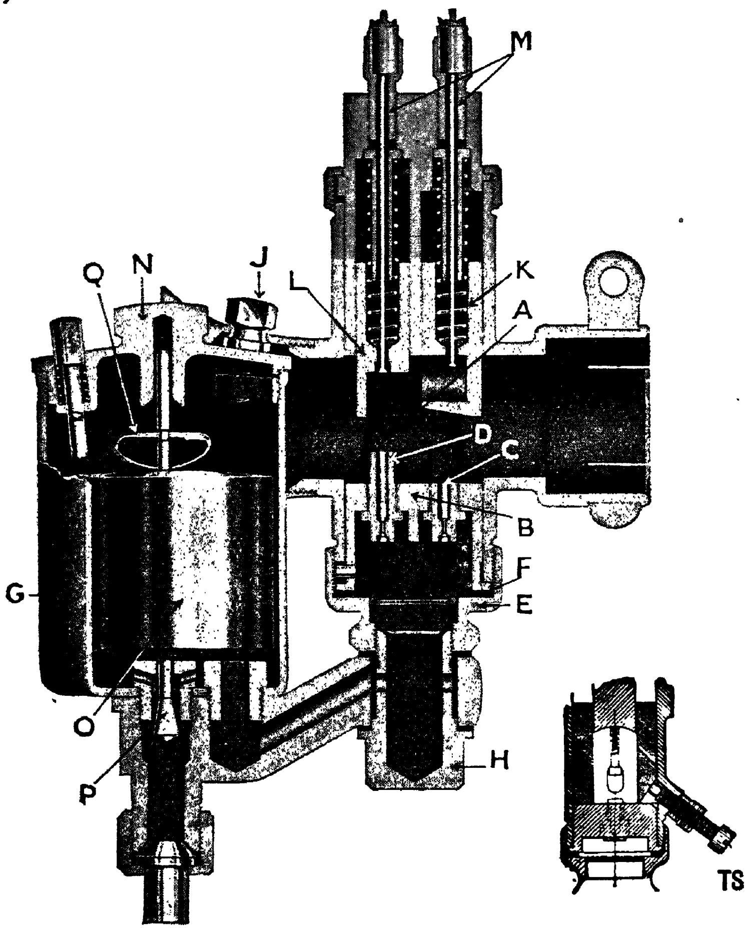


Fig. 118.—The Amal Non-Needle Type Carburettor.

A—Carburettor Body or Mixing Chamber.
B—Jet Block.
C—Pilot Jet.
D—Main Jet.
E—Union Nut.
F—Fibre Washer between Jet Block and Union Nut to ensure petrol tight joint.
G—Float Chamber.
H—Jet Plug securing Carburetter Body to Float Chamber.
TS—Throttle Stop.
T—Throttle Valve.
L—Air Valve.
M—Cable Adjusters.
N—Float Chamber Cover.
J—Float Chamber Cover Lock-nut
O—Float.
P—Needle Valve.
Q—Needle Valve Clip.

On the upper part of the jet block is the adaptor body H, forming a clean through-way.

Integral with the jet block is the pilot jet J, supplied through the passage K.

The adjustable pilot air intake L communicates with a chamber, from which issues the pilot outlet M and the by-pass N.

An adjusting screw (T.S.) is provided on the mixing chamber wall, by which the position of the throttle valve for "idling" is regulated independent of the cable adjustment.

The needle jet O is screwed in the underside of the jet block, and carries at its bottom end the main jet P. Both these jets are removable when the jet plug Q, which bolts the mixing chamber and the float chamber together, is removed.

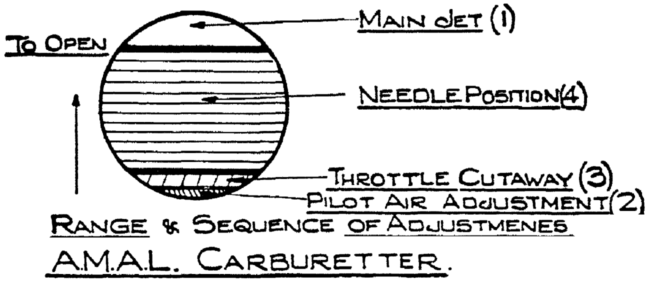


Fig. 119.

The float chamber, which can be supplied with either top or bottom feed, consists of a cup R suitably mounted on a platform S, containing the float T and the needle valve U attached by the clip V.

The float chamber cover W has a lock screw X for security on the large float chamber only.

The quantity of mixture capable of being passed by the pilot outlet M is insufficient to run the engine. This mixture also carries excess of fuel. Consequently, before a combustible mixture is admitted, throttle valve B must be slightly raised, admitting a further supply of air from the main air intake.

The further the throttle valve is opened, the less will be the depression on the outlet M, but, in turn, a

higher depression will be created on the by-pass N, and the pilot mixture will flow from this passage as well as from the outlet M.

The mixture provided by the pilot and by-pass system is supplemented at approximately $\frac{1}{8}$th throttle by fuel from the main jet system, the throttle valve cut-away governing the mixture strength from here to $\frac{1}{4}$-throttle. Proceeding up the throttle range, mixture control by the position of the needle takes place from $\frac{1}{4}$- to $\frac{3}{4}$-throttle, and thereafter the main jet is the only regulation.

The air valve D, which is cable-operated on the two-lever carburettor and hand-operated on the single-lever carburettor, has the effect of obstructing the main through-way, and, in consequence, increasing the depression on the main jet, enrichening the mixture.

Tuning the Amal Carburettor.*—In view of the comparatively large number of machines fitted with this make of carburettor, the following notes on tuning may be found helpful:—

There are four ways in which the mixture strength can be varied, the following being the items in question in their correct adjustment sequence:—

(1) Main jet ($\frac{3}{4}$ to full throttle);
(2) Pilot air adjustment (closed to $\frac{1}{8}$ throttle);
(3) Throttle valve cut-away on air intake side ($\frac{1}{8}$ to $\frac{1}{4}$ throttle); and
(4) Needle position ($\frac{1}{4}$ to $\frac{3}{4}$ throttle). (Fig. 119.)

(1) *Main jet size.*—Select the smallest jet which gives maximum speed with air lever three-quarters full open.

(2) *Pilot air adjustment.*—The slow-running mixture is weakened by screwing pilot screw outwards and enriched by screwing it inwards. These adjustments should be carried out when the engine is thoroughly warmed up. After warming up, reduce the engine speed by closing the throttle slowly. The slow-running mixture, when pilot air screw is screwed

* 1929 to 1937 Models.

home in a clockwise direction will then be too rich, so that it should gradually be screwed outwards. The engine speed will then increase, and must again be reduced by gently closing the throttle, until by a combination of throttle and pilot screw manipulation the desired "idling" speed is secured. It may be necessary to retard the ignition for good "idling" results. The throttle stop screw should be adjusted so that engine will "idle" with the throttle valve closed, and the throttle lever closed as well.

(3) *Throttle valve cut-away.*—If the "idling" has been correctly adjusted, set the magneto control at half-advance and the air lever fully open.

Open the throttle valve very slowly, when, if the engine responds regularly up to one-quarter throttle, the valve cut-away is correct.

A weak mixture is indicated by spitting back through the air intake with blue flames, hesitation in picking up, which disappears when the air lever is closed down, and this can be remedied by fitting a throttle valve with less cut-away.

A rich mixture is shown by black smoke from the exhaust. Engine stops, or nearly stops, when the air valve is closed. The remedy for this is a throttle valve with more cut-away.

Each Amal valve is stamped with two numbers, the first indicating the Type No. of the carburettor, and the second figure the amount of cut-away on the intake side of the valve in sixteenths of an inch.

Thus 6/4 is a Type 6 Valve with 4/16 in. or ¼ in. cut-away. The standard valve for single cylinder engines is No. 5, and for multi-cylinder engines, No. 4.

(4) *Needle Position.*—Needle positions are counted from the top of the needle, and the groove nearest the needle top is No. 1.

With air full open.

Open the throttle half-way.

Note if the exhaust is crisp and the engine lively.

Close air valve slightly below throttle, exhaust note and engine speed should then remain practically unaltered.

Weak mixture.—Raise needle in throttle valve. If —popping back and spitting occur with blue flames from carburettor intake.

Test by lowering air valve gently. Engine revolutions will rise when air valve is lowered slightly below the throttle valve.

Rich mixture.—Lower needle in throttle valve. If —engine speed does not increase progressively as the throttle is raised; smoky exhaust and heavy laboured running; on closing air valve slightly below throttle valve, tendency to miss-fire and eight-stroke is present.

The normal needle setting is with the needle clip in No. 3 groove.

Having found the correct needle position, the carburettor setting is now complete, and it will be found that the driving is practically automatic once the engine is warmed up.

For a semi-automatic setting, where extreme economy is desired, lower the needle one groove further after carrying out this range of tests.

For *speed work* the main jet may be increased by 10 per cent., when the air lever should be fully open when on full throttle.

"*Rich mixture*".—General indications are—heavy thumpy running, emission of black smoke from the exhaust, the inside of the carburettor becomes blackened, and as the throttle is opened, heavy "blow-back" of fuel is observed from the carburettor air intake.

"*Weak mixture*".—Difficult starting, tendency for the engine to fire back through the carburettor, indicated by blue flames from the carburettor air intake. Carburettor becomes sensitive to "drive", and constant use has to be made of the air lever, engine knocks readily and runs hot, with loss of power. The electrode of the sparking plug shows indications of intense heat, and the mica insulation becomes white. Polished exhaust pipes rapidly become blued.

The Amal Non-Needle Type Carburettor.—This simpler form of two-jet carburettor is intended for

use where the finer arrangements for tuning are unnecessary; it has been developed from the original Binks' motor-cycle carburettor, and can also be used satisfactorily for two-stroke, stationary and small marine engines.

In regard to the operation of this carburettor, the pilot jet regulates the mixture strength for slow running and at lower positions of the throttle. The

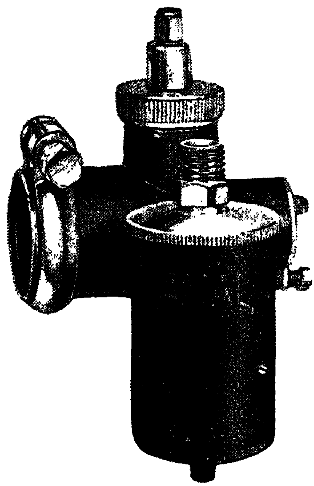


Fig. 120.—The Amal Non-needle type Carburettor.

main jet—situated near the air intake—comes into action when unmasked by the throttle valve and regulates the mixture strength up to full throttle. The mixture strength at intermediate throttle positions (viz., between $\frac{1}{4}$ and $\frac{5}{8}$ throttle openings) can also be corrected by varying the amount of cut-away on the air intake side of the throttle valve. An air control is provided for starting from cold.

The controls of this carburettor are by flexible cables, or single or double levers attached to the top of carburettor for operation by rod control—in the case of stationary engines.

Amal Acceleration Pump Carburettor.—This particular model corresponds to the modern car carburettor having an acceleration pump for supplying the extra quantity of petrol required for rapid acceleration on suddenly opening the throttle.

The carburettor (Fig. 121) consists essentially of a pump chamber, the top orifice of which replaces the existing needle jet. The pump chamber carries a piston fitted with a non-return ball valve, and a light

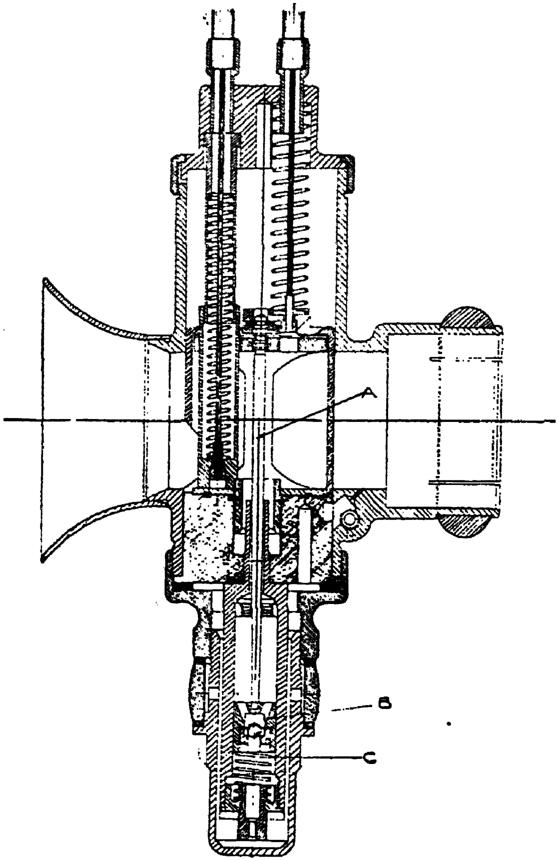


Fig. 121.—Amal Acceleration Pump Carburettor.

spring for the purpose of impelling the piston upwards. The bottom of the pump chamber is closed by a cap into which the main jet of the carburettor is fitted.

The action of the pump is as follows:—

When the throttle is closed, the throttle valve needle (A) presses down upon the piston (B) forcing it to the bottom of the pump chamber, the spring (C) being compressed. On rapidly opening the throttle

valve, the needle is withdrawn, the spring drives the piston upwards, forcing the petrol contained in the pump chamber through the needle jet into the spraying chamber, thus momentarily providing an extra rich mixture. This materially assists a quick get-away, and avoids the "flat spot" which might otherwise occur in these circumstances. When the throttle is closed again the needle forces the piston down, the ball valve (D) opening and allowing the pump chamber to refill with petrol. Thus the carburettor does not rely entirely upon atmospheric pressure to obtain rapid delivery of fuel when maximum acceleration is required.

If, for any reason the pump attachment is taken apart, it is important when re-assembling to see that the piston (B) is fitted the correct way up, i.e., with the four holes uppermost.

It may be mentioned that this carburettor is applicable principally when petrol or petrol-benzol fuels are used, but under certain conditions it can also be used successfully on alcohol fuel, provided the main jet necessary does not exceed 500 cc.

The Amal Track Racing Model.—The carburettor shown in Fig. 122, has been designed to meet the needs of track racing machines and the use of alcohol fuels. It belongs to the plain jet class, and embodies a pilot jet and a by-pass to ensure easy starting. It has a clear passage (at full throttle opening) for the mixture, so that the maximum volumetric efficiency can be obtained.

An air valve situated on the side of the carburettor body enables the mixture strength to be regulated without causing any obstruction to the main mixture passage. Twin float chambers are fitted.

The carburettor is made in three different sizes for engines of 250 to 350 c.c.; 350 to 500 c.c., and 500 c.c. and larger sizes of engine.

When the carburettor is used for alcohol fuels in addition to a special larger jet (marked "A"), another type of jet block is also employed.

The tuning of this type of carburettor is done in three stages, as follows:—(1) The main jet (three-quarter to full throttle); (2) the pilot screw (closed to

one-eighth throttle); and (3) the throttle valve cut-away (one-eighth to three-quarter throttle); the tuning is carried out in the order mentioned.

The *main jet* size should be the smallest which will give maximum speed, the air lever being about three-quarter full open during the tests.

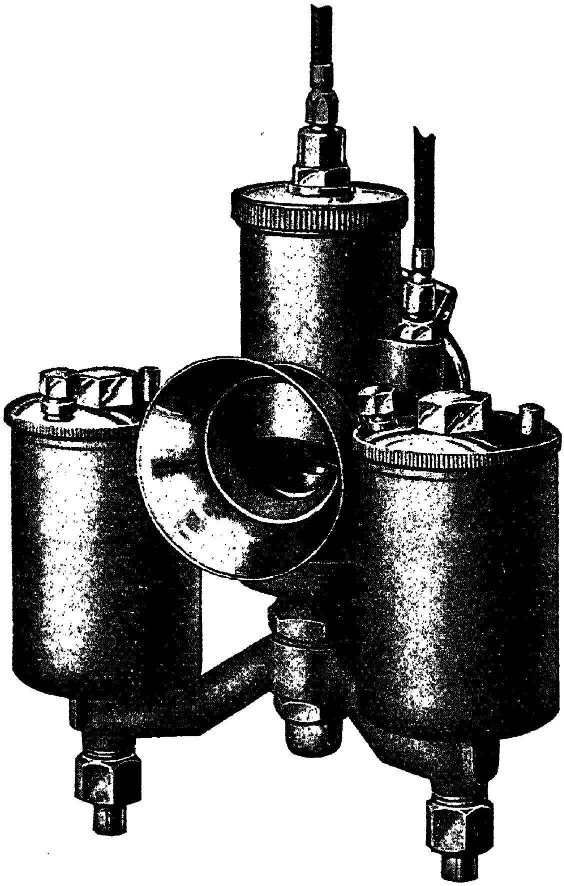


Fig. 122.—The Amal Twin Float Track Racing Carburettor.

The pilot jet mixture is weakened by screwing the pilot air adjuster outwards and enrichened by screwing it inwards.

In regard to the throttle cut-away, after adjusting the slow-running as previously explained, open the

throttle valve slowly, when, if the engine increases speed regularly the valve cut-away is correct.

A weak mixture is indicated by spitting back through the air intake, and as a second check on this weak flat spot it will be found that if the air lever is closed the flatness will disappear, this pointing to the fact that a throttle valve with less cut-away is required.

A rich mixture, which is shown by black smoke from the exhaust, coupled with erratic running or eight-stroking, and which again is accentuated when the air valve is closed, points to the fact that a throttle valve with more cut-away is required. The number of cut-away is stamped on the top of the throttle valve, the higher the number the greater the cut-away.

The standard valve for single cylinder engines is a No. 12.

Having obtained correct "idling", throttle valve number and main jet size, the setting should be now in order.

The pilot slow-running air screw is normally unscrewed about 2½ turns for petrol, and about one-half turn for alcohol fuels.

It is also unnecessary to alter the throttle valve cut-away when changing from petrol to Discol (alcohol mixture).

The twin-float chambers are recommended for alcohol fuels on engines of 350 c.c. and upwards. The fuel supply pipes should not be smaller than ¼ in. inside diameter.

Amal T.T. Carburettors.—These resemble externally the Amal Track carburettors previously described, but they have been modified from time to time, and are known as the T.T. 35 and 36, etc., in the later patterns, since they were fitted to T.T. motor cycles of 1935 and 1936, and so on.

In regard to these patterns, the choke, or effective bore, has an important bearing on maximum speed. The choke has its smallest diameter between the throttle barrel and the outlet; not immediately over the jet as in earlier designs. This minimises any restriction caused by the needle, and gives a higher volumetric efficiency than in previous models.

In connection with *the choke size*, this depends not only upon the size of the engine, i.e., the bore and stroke, but also upon the maximum engine speed. Thus, in the case of a 500 c.c. engine, a carburettor bore of $\frac{15}{16}$ in. would be suitable for a maximum speed of 4,000 r.p.m., whilst one of $1\frac{1}{16}$ in. would be necessary for a maximum speed of 5,000 r.p.m.

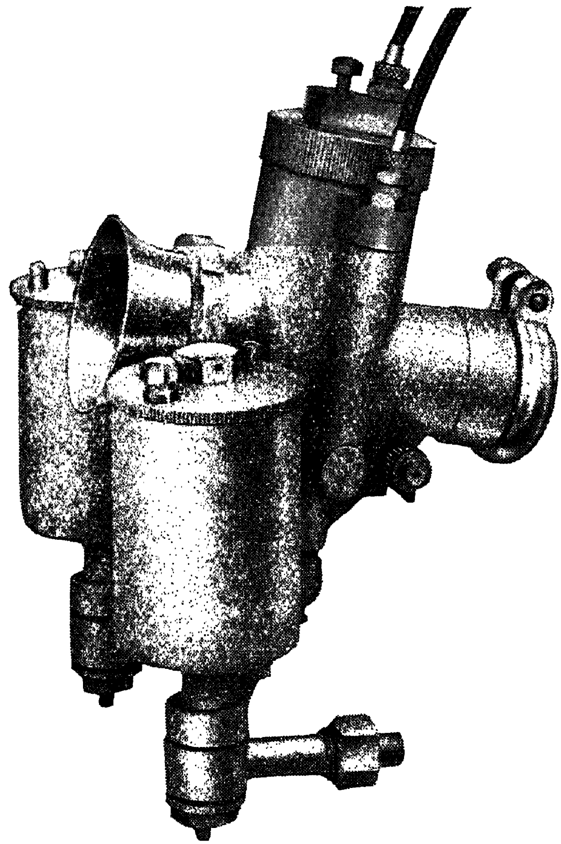


Fig. 123.—The Amal T.T. Carburettor.

In regard to *the fitting of the T.T. carburettors*, it is usual to allow a distance of some 5 to 6 ins. between the carburettor (centre) and the inlet valve; further, the bore of the carburettor outlet should be smoothly continuous with that of the inlet passage. Flange

fitting is recommended to insulate the carburettor from the heat of the engine.

The T.T. carburettors are available in the vertical, horizontal or down-draught patterns—in the latter case, however, the barrel is inclined to conform with the shape of the induction port.

For twin engines, a separate carburettor to each cylinder generally gives appreciably better results.

Tuning the T.T. 36 Carburettor.—There are four items concerned with the tuning of this model; they are, in the sequence of tuning:—(1) Main jet size; (2) pilot jet adjustment; (3) throttle valve cut-away; and (4) needle attachment.

(1) *Main Jet Size.*—This should be determined first: the smallest jet which gives the greatest maximum speed should be selected, keeping in mind the safety factor for cooling. (*The air lever should be fully-open during these tests.*)

(2) *Pilot Jet Adjustment.*—Before attempting to set the pilot adjuster, the engine should be at its normal running temperature, otherwise a faulty adjustment is possible, which will upset the correct selection of the throttle valve. The pilot adjuster which controls the amount of fuel passed, is rotated clockwise to weaken the mixture, and anti-clockwise to enrich it. Adjust this very gradually until a satisfactory tick-over is obtained, but take care that the achievement of too slow a tick-over—that is, slower than is actually necessary—does not lead to a "spot" which may cause stalling when the throttle is very slightly open.

(3) *Throttle Valve Cut-Away.*—Having set the pilot adjuster, open up the *throttle* progressively and note positions where, if at all, the exhaust note becomes irregular. If this is noticed, leave the throttle open at this position and close the air lever slightly; this will indicate whether the spot is rich or weak. If it is a rich spot, fit a throttle valve with more *cut-away* on the air intake side (or *vice versa* if weak).

(4) *Needle Attachment.*—This tuning sequence will affect carburation up to somewhere over one-quarter throttle, after which the jet *needle*, which is suspended

from the throttle valve comes into action, and when the throttle is opened further and tests are again made for rich or weak spots, as previously outlined, the needle can be raised to enrich or lowered to weaken the mixture, whichever may be found necessary.

With these adjustments correctly made, and the main jet size settled, a perfectly progressive mixture will be obtainable from tick-over to full throttle.

Needle Jet.—It is not necessary to alter the needle jet when tuning, but before attempting to set the carburettor, the rider should make sure that the correct needle jet is fitted. The following are the needle jets which should be used:—

Carburettors up to $1\frac{1}{32}$ in. bore: petrol fuel; needle jet ·1075.

Carburettors over $1\frac{1}{32}$ in. bore; petrol fuel; needle jet ·109.

Carburettors used with alcohol fuel; needle jet ·113.

Alcohol Fuels.—When alcohol fuel is used, the needle jet mentioned above must be fitted, and it is also necessary to increase the main jet by the following amounts:—

Discol P.M.S.2 fuel: 60 per cent. greater flow than for petrol.

R.D.1. fuel: 80 per cent. to 100 per cent. greater flow than for petrol.

Pratt's Racing Spirit: 200 per cent. greater flow than for petrol.

J.A.P. Racing Fuel: 150 per cent. greater flow than for petrol.

The jets are designated by numbers which represent the quantity of petrol flowing in c.c.'s, under given conditions, using an Amal flow-meter.

The manufacturers supply a table of jet sizes and c.c. flow values.

The Triumph Carburettor.—This is an efficient Amal model, provided with Bowden wire controlled throttle and air slides.

An adjustable pilot jet is employed. The fuel supply, which is controlled by a tapered needle, should be adjusted to approximately three-quarters of one

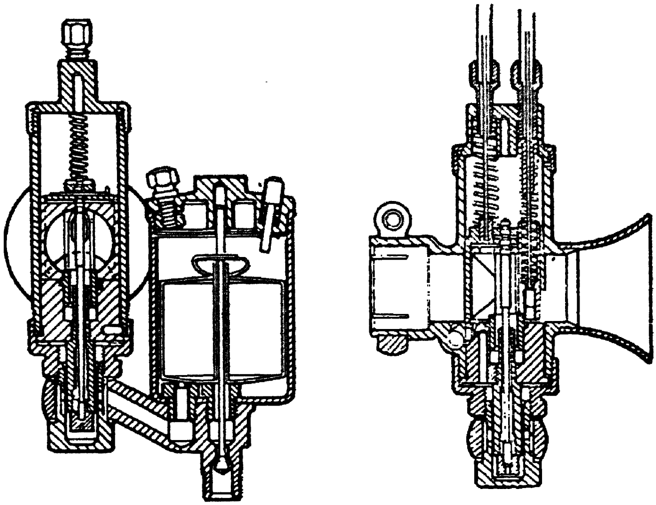


Fig. 124.—The Amal Carburettor as used on Triumph Engines.

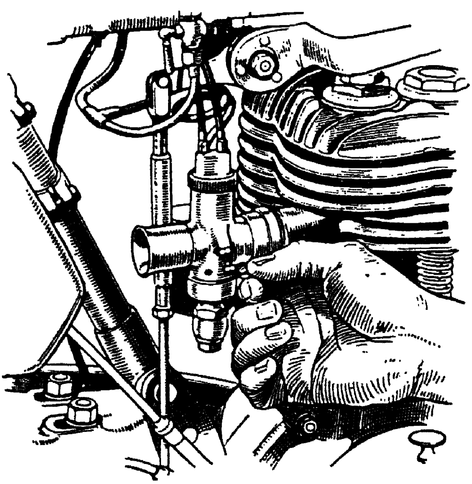


Fig. 125.—Adjusting the Triumph Amal Carburettor.

complete turn in an anti-clockwise direction from closed position. It is most important that no undue

force is exerted in shutting off the pilot needle valve —otherwise the needle and seating may become seriously damaged.

"All-out" mixture strength with the air lever fully open should next be determined, this being governed in the full throttle position by main jet size only, the smallest jet which gives the maximum speed being the correct size. After this has been decided intermediate running and acceleration should be dealt with. If it is found that the mixture is too rich a throttle valve with more cut-away should be tried. On the other hand, if the mixture is too weak, a valve with less cut-away should be used. The higher the number stamped on the valve, the bigger is the cut-away.

It is important that the correct jet size for "all-out" should be obtained for general running. It is well to bear in mind that the cut-away of the throttle valve does not have any effect on the "all-out" position.

The Villiers Carburettor.—All Villiers engines are fitted with a specially designed carburettor supplied by the makers. The carburettor in question belongs to the automatic class in which a tapered needle works in the fixed petrol jet, the needle being attached to the throttle so that as the latter is opened or closed the needle enlarges or reduces the annular jet area. There is no separate air control in this carburettor.

There were originally two different models, as follows:—

(1) *The Single Control Type.*—In this case there is a single Bowden control for the throttle, operated by a lever on the handle-bar. There is also a special lever on the top of the throttle slide cylinder having a quick thread for moving the needle up or down independently of the Bowden control. The mixture can, therefore, be altered in strength for starting or tuning purposes. This lever has extreme positions marked "Weak" and "Rich," and is only used for altering the mixture setting—not as a driving control.

(2) *The Double Lever Type.*—This works on the

same principle as before, but instead of having a mixture control lever on the top of the carburettor, there is a Bowden control for altering the position of the needle in the jet.

Fig. 126 gives a sectional view of this carburettor. In this case the tapered needle is shown at *C*, the jet at *B*, and the separate jet needle control at *D*.

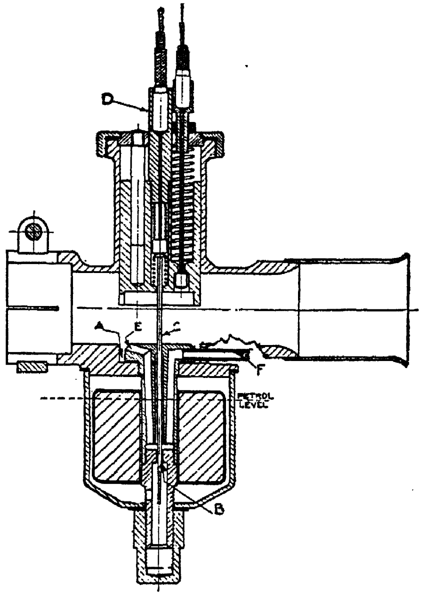


Fig. 126.—Earlier Pattern Villiers Carburettor.

The suction of the engine on the orifice *E* draws a stream of air through the compensating tube *F* across the top of the jet *B*, where it helps to atomize the petrol coming from the jet at *E*. This device assists in maintaining constant mixture strength at all engine speeds.

Villiers Midget Carburettor.—The smallest sizes of Villiers two-stroke engine are fitted with the Midget carburettor, shown in Fig. 127. This has a concentric float and float chamber supplied through the needle valve F from an overhead pipe through a filter E

The float chamber has a "tickler" at B. The carburettor acts on the same principle as the one previously described.

It has a compensating tube (shown inclined in Fig. 127, near the air strangler A), air being drawn across the top of the jet to assist in atomizing the petrol. A taper needle valve D, operating in conjunction with the throttle C, serves to maintain a uniform mixture strength at all throttle openings.

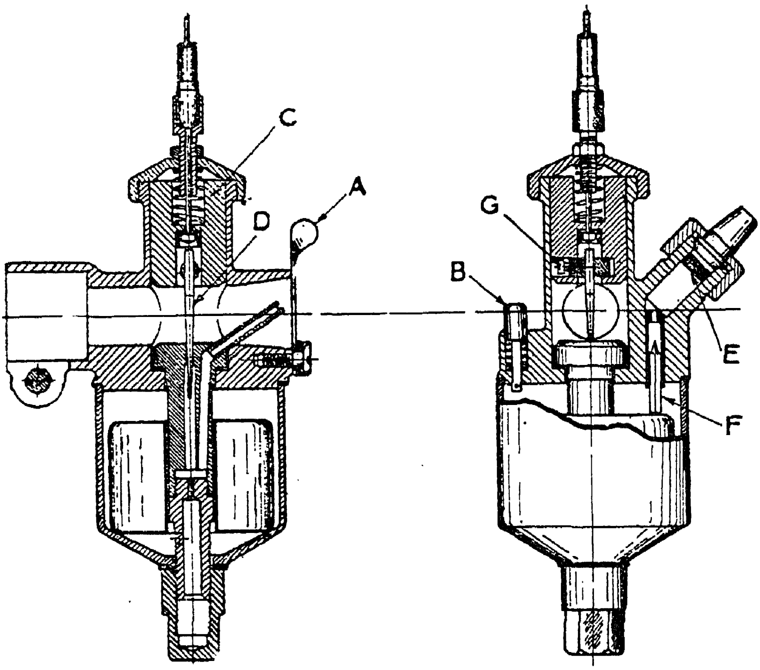


Fig. 127.—Villiers Midget Carburettor.

The instructions for *starting* are as follows:—

Close strangler (A), press tickler (B) until petrol appears. Open throttle about 1/3, and engine should start easily. Gradually open strangler (A) as engine warms up until fully open. If correctly set, engine should give good two-stroking in the tick-over position, and take full throttle without hesitation when warm.

In regard to the *general maintenance* of this carburettor:—

If four stroking occurs, throttle slide (C) should be withdrawn, and needle (D) lowered 1/64 in. at a time, by slacking off screw (G) and then re-tightened.

If firing back through the carburettor occurs, needle (D) should be raised in the same manner.

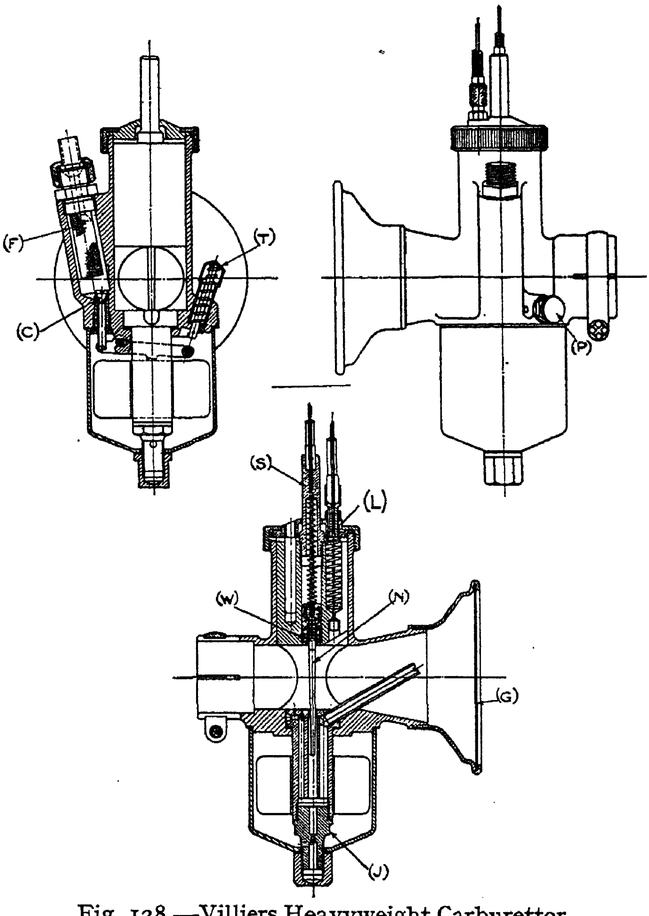


Fig. 128.—Villiers Heavyweight Carburettor.

Filter (E) should be cleaned periodically or petrol will not flow freely. On no account should it be left out, or grit, etc., will get into the needle (F) seating, and cause flooding.

Villiers Heavyweight Type Carburettor.—Known as the H/W Type carburettor, this resembles in general design the Midget model, with the exception of the additional air slide L and pilot jet. It employs the same concentric float chamber and float as the Midget.

The pilot jet (Fig. 128) is arranged to govern the carburettor up to about one-quarter throttle opening. A screw (P), is provided for enrichening or weakening the pilot jet mixture; the mixture is enrichened by screwing the adjustment clockwise.

The standard needle (N) fitted, is the No. 2 size. The main mixture strength can be enrichened by raising the needle. If, however, this is not enough to improve the acceleration, a larger size needle, viz., No. 3 should be fitted. The smallest needle, No. 1, is employed for weakening the mixture.

The main jet (J) governs the maximum speed; it has no effect at the smaller throttle openings.

To adjust the needle unscrew the top sleeve (S) out of the slide, and withdraw needle control complete. Extract small "U" shaped wire (W) and re-insert in another groove in needle, raising latter to get richer, and lower to get weaker.

The needles are marked "One", "Two", etc., on the extreme top.

The petrol filter (F) should be cleaned periodically or petrol will not flow freely. On no account should it be taken off union, or grit, etc., will get into the needle seating (C), and cause flooding. The air filter gauze (G) should be kept clear of dirt, etc., by washing in petrol.

The engine to which this carburettor is fitted is *started from the cold*, as follows:—

Press tickler (T) until flooding occurs, open jet control lever to full rich position, and open throttle about one-third. One or two kicks on the starter should start the engine. When warm close jet lever as required until in set position at bottom of slide.

The Senspray Carburettor.—This carburettor, which was hitherto used on light car and motor-cycle engines, has a number of original features, the principal one of which is the very high velocity atomizing air stream which rushes across the top of the fuel jet and produces a "mist" somewhat on the lines of the scent-spray. The atomizing venturi near the jet is of small dimensions and produces a very rich fuel-mist-air mixture, which mixes with the main air supply, which is admitted straight in at the back of the carburettor. A cylindrical type throttle is

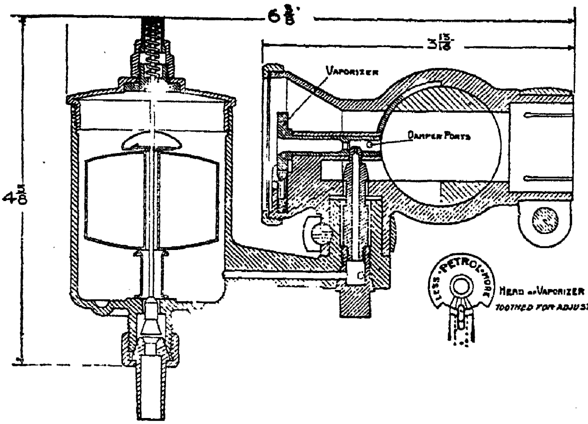


Fig. 129.—Sectional View of the Senspray Carburettor, showing the Atomizer, Damper Ports, and Cylindrical Throttle.

fitted, which, in addition to controlling the quantity of mixture admitted, also regulates the air supply by its specially shaped port. When the throttle opening is small, there is only a small air inlet opening, and consequently some of the air passing through the carburettor will enter by way of the small "damper holes"* in the atomizing tube; this reduces the quantity of air drawn through the atomizing tube and thus reduces the fuel supply. The more the throttle is opened, the larger becomes the air inlet and the less the amount of air admitted through the "damper holes." When the throttle is full open a greater quantity of air is drawn through the atomizing tube, and the maximum quantity of fuel

*Shown just on the right hand side of the jet.

CHAPTER VII

PARAFFIN AND OTHER CARBURETTORS

Paraffin Carburettors.—Although not used to any appreciable extent on motor-cars, these have been employed on the larger commercial vehicles, motor tractors, motor boats, and stationary engines, so that a brief account will not be out of place here.

In the case of ordinary car engines, the more elaborate vaporizing apparatus required, extra starting trouble and the lower power output are the principal reasons against this fuel, although in the times when petrol was restricted in supply or costly, it was often used.

Modern high speed engines do not work at all well on paraffin, due principally to their compressions and speeds being too high. Paraffin gives the most satisfactory results on medium or low compression* medium speed engines of ample dimensions for the power requirements. The difficulty of vaporizing and regulating the mixture under the varying conditions of the road are then not met with, and the starting difficulty is not such a serious item.

The *usual method of employing paraffin* in motor vehicle engines is to vaporize the fuel mixture taken from an ordinary spray carburettor in a special exhaust heated vaporizer, employing a rich mixture for the purpose, and to use a separate supply of petrol, with a two-way change over cock, for starting purposes. Sometimes two float chambers are fitted to the one carburettor, as in the Binks' type.

Methods Employed.—There are three primary methods of using paraffin-air mixtures, as follows:—

* From 60 to 90 lbs. per sq. in. compression pressure.

1. The *Wet Mixture Method*, which employs a rain-like "mixture," consisting of large drops forming a stream-like film on the walls of the inlet pipe and passages. This "mixture" is rather erratic, and does not respond satisfactorily to speed and load changes, nor does it give a good mixture distribution in multi-cylinder engines. It has given good results in stationary single cylinder engines, or where a separate carburettor is fitted to each cylinder. The mixture is far from homogeneous, and in the ordinary way causes overheating. This necessitates some additional cooling means, such as water-injection. The latter method reduces the internal temperature, lowers the flame propagation rate and probably raises the ignition temperature.

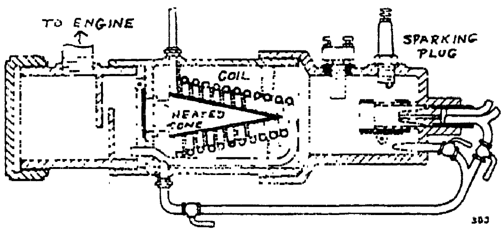


Fig. 131.—The Porter-Rider Fog Mixture Paraffin Carburettor, with Combustion Type Vaporizer.

2. In *the Fog Method*, the paraffin is in suspension in the air supply, in the form of very fine drops, as in a fog or mist. These mixtures can exist quite cold, and be compressed readily in most medium compression petrol engines, with a good volumetric efficiency, owing to the low intake temperature. The distribution is not so good, however, as with the dry mixtures, and there is a tendency to form liquid films on the walls of the inlet pipe and passages, with the resulting drawbacks of the wet method.

Fig. 131 illustrates one type of fog mixture apparatus, known as the Porter-Rider, in which the paraffin is sprayed by means of compressed air from the nozzle shown on the right, the spray being ignited by the electric sparking-plug shown above. This causes some of the oil present to burn in the

limited amount of air admitted so that the rest is vaporized. The flame is extinguished by its impingement on a cooling coil, and the hot vapour with the products of combustion of the ignited oil mix later with the main stream of cold air, a fog mixture being thus formed by condensation. In another method the exhaust heat is employed to actually boil the paraffin, a water condenser being used to prevent the temperature of the vapour from rising too high. The hot vapour is then mixed with a cold air supply, where it forms a fog mixture.

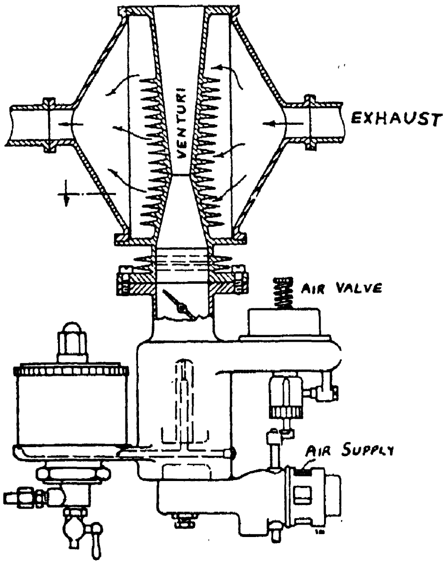


Fig. 132.—A Typical Exhaust Heated Venturi Vaporizing Device for Paraffin Carburettors.

3. *The Dry Method.* In this system the charge contains the fully vaporized fuel, and the resulting paraffin-air mixture is in the form of a clear transparent gas. It is necessary to maintain the walls of the inlet at a sufficiently high temperature to prevent fuel deposition. Dry mixtures are considered the best for multi-cylindered engines, as they behave like gases in regard to distribution; smoke and carbon deposits are also avoided. On the other hand the mixture is fairly warm, and the volumetric efficiency is therefore lower, due to the lighter weight of this warm mixture. The

vaporizing temperatures employed vary from about 250° to 500° F., for paraffin, depending on the type of vaporizer employed. The dry mixture can readily be obtained by heating a sprayed paraffin air mixture in a suitable exhaust-jacketed manifold so designed that all of the mixture comes into contact with the walls of the vaporizer; the method is much used in oil engine practice. Fig. 132 illustrates one form of venturi exhaust heater, in which intimate contact of the mixture with the walls is ensured.

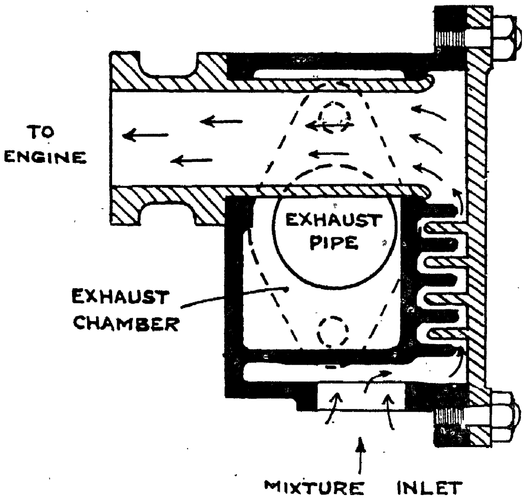


Fig. 133.—The Binks Paraffin Vaporizer.

The Binks' Two Fuel Carburettor.—The vaporizing system illustrated is one which was used to some extent on automobile engines; it employs petrol for starting purposes, and until the exhaust heated vaporizer is sufficiently hot to vaporize the heavy fuel used; the latter may be paraffin or white spirit. It consists of a metal box through which runs a rectangular tube or exhaust box, through which the engine exhaust gases pass. On the side of the pipe are placed a number of longitudinal fins, as shown in Fig. 133. The carburettor is attached to the vaporizer on the lower side. The lid has a number of similar ribs; when fixed in position the ribs on the lid lie between the ribs on the exhaust pipe, so that the

sprayed fuel and air mixture, under the influence of the engine's suction, take a zigzag path into the cylinders. The fuel particles are thus brought into intimate contact with the heated surfaces and are vaporized.

The two-float carburettor is provided with a two-way tap, the handle of which is placed conveniently to the driver, so that fuel may be changed over readily.

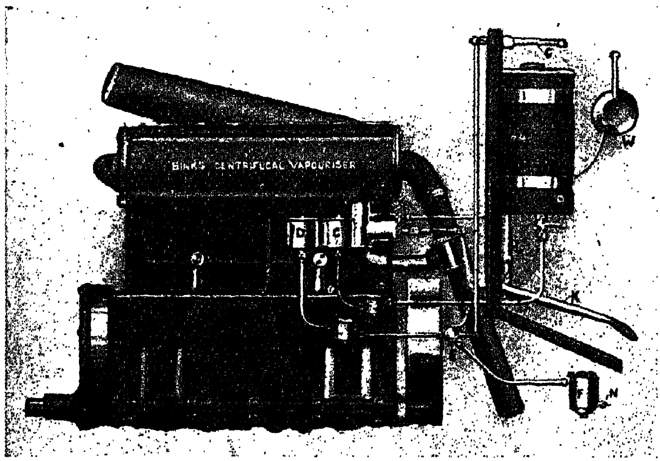


Fig. 134.—The Binks Two-Jet Carburettor, shown fitted to a Car Engine.

A—Centrifugal Vaporizer.
B and M—Exhaust Pipe.
C—Petrol Float Chamber.
D—Heavy Fuel Float Chamber.
E—Change-over Cock.
F—Fuel Filters.
G—Operating Lever for Change-over Cock.
H—Petrol Tank.
J—Air Supply.
K—Throttle Control (Accelerator).
N—Heavy Fuel Supply.

It requires about three minutes running on petrol before the paraffin supply can be switched on. It is necessary, of course, to have a spare petrol tank of about one to two gallons capacity; a gravity feed from the dash-board can often be arranged for this supply. An air supply with lever control is also supplied with this vaporizer. It is claimed that under ordinary conditions an automobile engine will run on paraffin, at about one-half the cost of petrol.

The Holley Paraffin Carburettor.—This type has been used upon Ford cars and tractors. In the earlier forms two float chambers were employed, one for

paraffin and the other for petrol (for starting purposes). In a later model designed for cars and tractors, only one paraffin float chamber is used, but there is a separate petrol-air mixing device. The paraffin is vaporized by being drawn through an exhaust heated copper coil, leading to a two-way cock, whence it can pass into the inlet manifold after mixing with cold air. Fig. 135 illustrates the carburettor in question. Referring, firstly, to the left hand view, the petrol for starting is drawn by the engine suction from

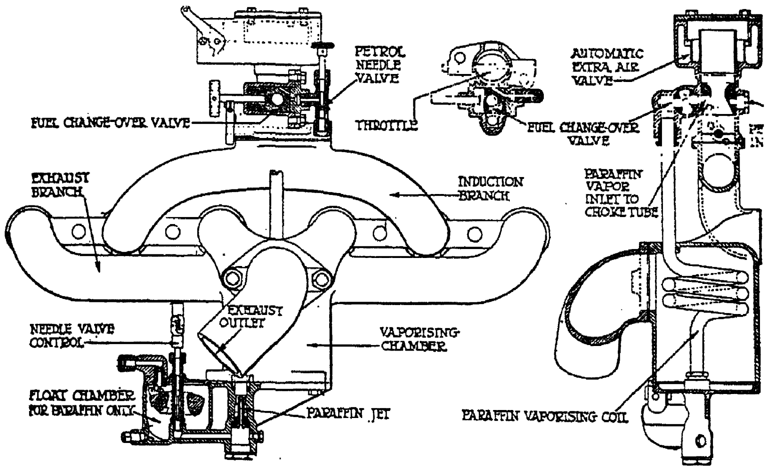


Fig. 135.—The Holley Paraffin Carburettor.

a quart capacity tank on the dashboard, below the level of the petrol needle valve shown, and an air supply. The needle valve is adjusted to give the best running results and locked in position. After the engine has run on petrol for about two minutes the two-way cock shown above is given a quarter turn, when it cuts off the petrol and places the vaporizing coil in communication with the engine. The engine suction then draws paraffin through a special type of jet, in the form of a tube in which rests a conically seated valve, having a small slow-running central hole. At higher speeds the engine suction lifts the valve and admits the main supply of fuel. The fuel supply increases automatically with the air supply. It will be seen that the paraffin is vaporized by the exhaust gases surrounding the coiled copper pipe, when the rich mixture passes

outside the exhaust pipe to the change-over cock, after passing through which it is mixed with cold air from the automatic air valve shown at the top (right hand view, Fig. 135), thence passing down a choke to the butterfly throttle.

In effect this device appears to come into the second class referred to, namely the fog mixture one, for the admixture of cold air to a well vaporized rich mixture of paraffin and air will cause a partial condensation of the fuel. It is stated that this cooling, even after the rich mixture has passed through a 10 ft. pipe to the change-over cock, has no detrimental effect on the running of the engine.

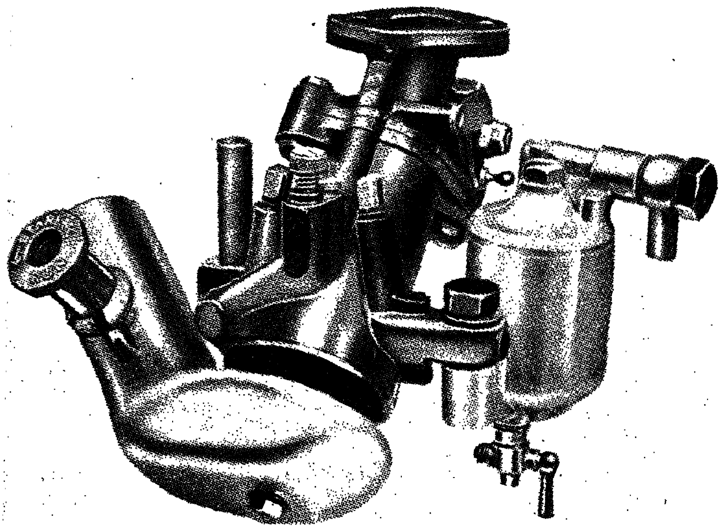


Fig. 136. The Gladwell Paraffin Carburettor.

The Gladwell Carburettor.—This paraffin carburettor has been in use for some years on agricultural tractors, stationary and marine engines of relatively low compression ratio, namely, less than about 4·5 : 1. It does not utilize the method of preheating the fuel or the air supply as it is contended that the expansion of the air due to preheating results in an appreciable reduction

in volumetric efficiency. The principle employed is to vaporise the paraffin by superheated air, the temperature of the hot rich gas thus produced being lowered to a suitable working temperature by mixing it with the main supply of slightly warmed air. This system ensures a ready response to the throttle and enables the engine to take up its load at once after it has been idling for some time.

The complete unit consists of the carburettor, air superheater and air warming chamber. The exhaust heat is employed for the two latter parts. The carburettor is arranged with a dual connection so that its float chamber can be supplied with either petrol—for starting and warming up purposes—or paraffin for normal running once the engine is hot. It is necessary to drain out the paraffin from the float chamber for starting from the cold; the warming up period is from 3 to 5 minutes. It is not possible, owing to space limitations, to describe the carburettor in detail, but a full account of this will be found in "The Automobile Engineer," October, 1939.

It is claimed that there is no loss of power as compared with petrol when running on paraffin, and that a fuel consumption of 0·6 pints (about 0·5 lb.) of paraffin per B.H.P. per hour is obtained. Very little dilution of the lubricating oil in the engine sump is experienced. It is necessary to employ a rather different kind of sparking plug than for petrol engines, as the latter type are liable to become too hot and to cause pre-ignition; special plugs are available for paraffin operated petrol engines.

A Petrol-Producer Gas Carburettor.—The Solex Mixer Carburettor shown in Fig. 137* is designed for automobile type engines which are started on petrol and, when the gas producer is ready for operation can be changed over to operate on producer gas; it may also be used for coal gas.

The carburettor consists of the ordinary Solex petrol unit, but adjusted for starting purposes, and on the right the gas mixer having a main body with three

* Motor Transport, October 14th, 1939.

passages controlled by four butterfly throttles, namely, the interrupter, secondary air, producer gas and main engine ones. The driving throttle and petrol carburettor throttle are connected direct to the accelerator of the vehicle. The gas regulator and interrupter throttles are interconnected so that as the one opens the other closes; this allows for a gradual change-over from one fuel to the other or for running on the two fuels together. The secondary air throttle is controlled by a link from the main throttle, but it has also an adjustable hand control so that it can be closed independently when adjusting the air-gas mixture or

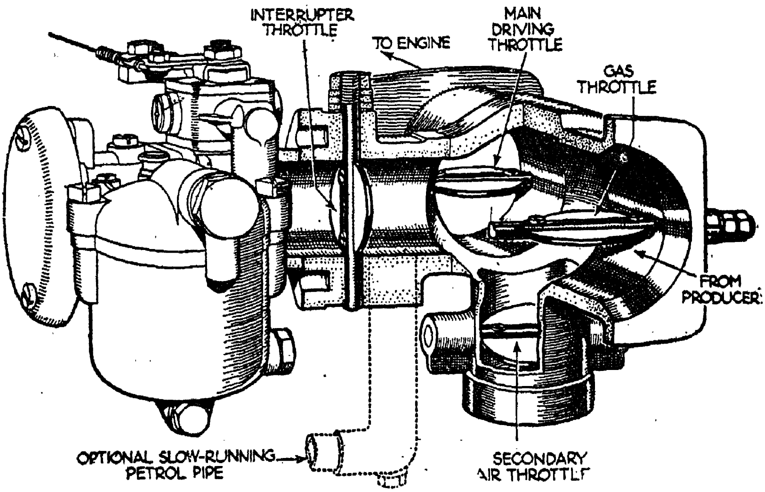


Fig. 137.—The Solex Petrol-Producer Gas Carburettor.

when starting on petrol. Two cable controls operated from the driver's seat are provided for these purposes; a push-pull control is also fitted for the petrol carburettor "self-starter" device. In normal use the main throttle is set to remain open sufficiently to permit idling on gas when warm and for starting on petrol the interrupter throttle is opened fully, whilst the other throttles are closed by the two controls previously mentioned. When the engine has warmed up the petrol carburettor self-starter and interrupter throttle are closed; the gas intake is opened at the same time and the vehicle is then driven by means of the accelerator pedal control.

Surface and Wick Type Carburettors.—A type of carburettor which was at one time very popular, but has since been replaced by the jet type, is that in which the petrol or benzene used was vaporized completely, usually by passing hot air over the surface of the fuel, or fuel-soaked cotton lamp wicks. The rich vapour laden mixture was then mixed with the correct proportion of air and admitted to the engine. The Lanchester wick carburettor described herewith was probably the last example of this type used on motor-cars in this country. The idea has since been revived, and a satisfactory type of carburation device made which employs combustible mixtures of fuel vapour and air, governed by a similar means to that employed in gas-furnace control. The earlier

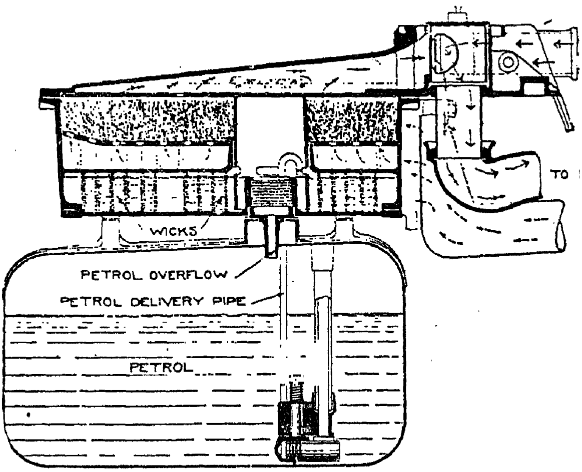


Fig. 138.—The Lanchester Surface Carburettor.

surface carburettors worked satisfactorily with the light spirit then available, but the more modern motor fuels have become heavier in density, and less easily volatilized, so that some of their heavier constituents would not volatilize in the ordinary surface carburettors. This remark does not apply, however, to the recent example mentioned above.

The Lanchester Surface Carburettor.—This type was used on the earlier Lanchester cars. It consisted of a petrol reservoir, or fuel chamber below, and a

special wick chamber above. Petrol was delivered into the lower part of the wick chamber by means of a plunger pump of the oscillating cylinder type, placed in the bottom of the petrol reservoir and driven by means of a vertical shaft and worm gear from the engine; it delivered rather more petrol than the engine required, the surplus being returned by means of an overflow pipe to the reservoir. Hot air from the exhaust pipe vicinity was drawn up through the loose wick ends in the upper part of the wick chamber, so as to form a richly laden air-petrol vapour mixture; this was too rich, however, for ordinary use, so was diluted by air admitted through the upper air pipe and valve shown in Fig. 138.

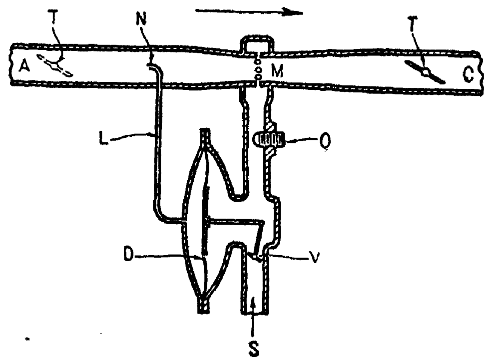


Fig. 139.—Illustrating the Principle of the Keith and Whatmough Carburettor.

The single-headed arrows show the hot air entering from the heater, whilst the double-headed ones show the carburetted air passing into the vapour regulator, where it is mixed with cold air before entry into the engine. The wick tank had a capacity of about 1 gallon.

Keith and Whatmough Carburettor.—This type utilizes a gas-control principle similar to that used in gas furnaces. Its use enables heavy fuels to be vaporized and used in internal combustion engines very satisfactorily. The principle can be followed from Fig. 139, which illustrates diagrammatically the gas furnace control device referred to. Assuming the fuel

has been vaporized satisfactorily, in the boiler portion described later, it is led through the pipe S, past a control valve V and "obturator" O, whence it passes through the holes M, and meets the main air stream in the venturi inlet pipe AC. The amount of gas admitted by V depends upon the pressure difference existing between the two sides of the diaphragm D. As the velocity in the pipe AC becomes greater its pressure becomes greater, and the diaphragm moves to the left, thus tending to open the valve V; the mixture is in consequence governed to suit the air flow. T is the ordinary throttle valve for regulating the quantity of

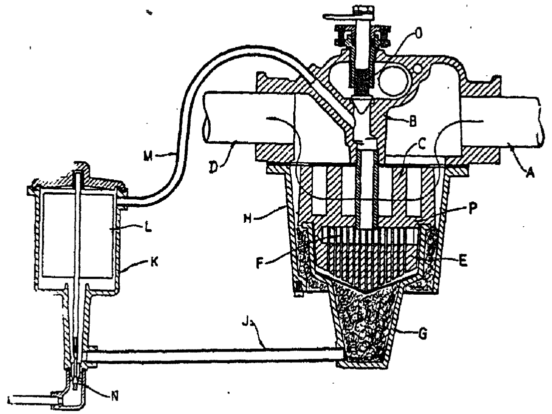


Fig. 140.—The Boiler, or Fuel Vaporizer.

mixture to the engine. The pressure difference set up between the two sides of the diaphragm varies as the square of the rate of flow.

In applying this system to combustion engines a fuel vaporizer, or boiler, similar to that shown in Fig. 140 was used. In this device the exhaust from the engine enters at A, and after impinging on the casing B, containing the governing mechanism, passes in the direction of the arrow, downwards to the boiler proper, which consists of a plate P having a number of staggered square pins between which the exhaust passes, and thence upwards to the exit D. Depending from the plate P, and in contact with the heated pins, is a block E intersected by a number of

vertical saw-cuts. A cross gas-way F connects the tops of these saw cuts with an upright gas-way leading to the governor. The depending portion is filled with metal chips. The whole boiler is surrounded by an outer casing H, which is lagged with slag wool below the level of P. An ordinary float chamber K controls the fuel level and admission. The vaporized fuel leaves by the stop-valve controlled exit shown at O. The governing part of this system (Fig. 141) dispenses with the flexible diaphragm shown diagram-

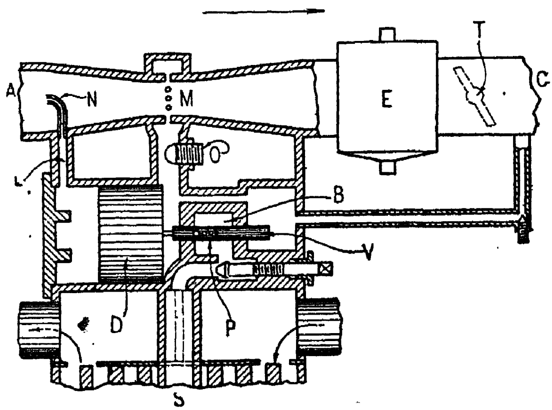


Fig. 141.—The Governing Device.

matically in Fig. 139, and employs in its place a piston D and its cylinder. The vaporized fuel enters at S, and goes to a belt B connected to the light metallic piston D. The valve V is shown fully opened, so that the ports P are also wide open to the gas in the belt B, which passes thence through the hollow stem of the valve to either end, so that the valve is in balance. If the piston D moves to the left by the rise of pressure on its inner surface, the valve V is withdrawn and the ports P are moved out of the belt. The port L corresponds with L in Fig. 139 The governed gas passes by way of the obturator O to the belt surrounding the constriction M on the induction pipe; the mixture passes to the engine by way of the pipe C. T represents the throttle, and E an ordinary spray carburettor used for heating

purposes. The device described has been tested on a car engine on the road, using heavy fuels (paraffin, alcohol, benzole and petrol) and mixtures of some of these. It was found necessary to employ an auxiliary carburettor to start the engine, and thus to heat the boiler. When the latter was heated sufficiently (about two minutes sufficing for alcohol, benzole or petrol, and five minutes for paraffin-benzole), the mixture supply could be switched over to the device in question. The engine was found to run satisfactorily, and could be throttled down to idle slowly. The obturator O is used to set a constant strength of mixture; its setting varies also with the fuel used; an increase in the opening is found necessary for benzole, and a considerable increase for alcohol, than for petrol or paraffin-benzole mixtures. It is found necessary also to maintain the mixture and induction pipe at certain minimum temperatures to prevent fuel deposition, this temperature varying from 40° to 100 C. according to whether the fuel was a light one (boiling point 80° to 130° C.) or a heavy one (boiling point 200° C. to 240° C.).

CHAPTER VIII.

COAL AND PRODUCER GAS SYSTEMS.

Gas Carburettors.—Petrol engines can be operated with certain combustible gases, such as coal gas, producer gas, suction gas, hydrogen, methane, etc., with satisfactory results. In many instances, notably when using coal or suction gas, appreciable economies in running costs can be achieved; for this reason a good deal of attention has, in the past, been given in France and Germany to motor vehicles running on certain gases.

In this country coal gas has been used in place of petrol on motor vehicles. Thus, during the Great War period it was a fairly common practice to use flexible gas containers—in the form of large rubber bags fitted on the roofs of vehicles. This low pressure method of storing the gas has the disadvantage of excessive bulk and wind resistance, however.

The method since adopted is to compress the coal gas into high tensile steel cylinders, such as Vibrac steel ones, and to supply the engine through a pressure reducing valve. With these cylinders, storage pressures up to 3,000 lb. per sq. in. can be employed, so that the bulk of the containers is comparatively small.

The cost of compressing the gas must, of course, be added to that of the coal gas itself in making any comparisons between gas and petrol running costs.

In this respect some data relating to the relative fuel costs, made at Birmingham*, may be of interest.

The cost of compressing coal gas worked out at 11d. per 1,000 cu. ft. With gas at 1s. 7d. per 1,000

* "The Utilization of Coal." *Journal of the Royal Society of Arts.* June 8th, 1934.

cu. ft., the total cost would be 2s. 6d. per 1,000 cu. ft. At the current rates this cost was equivalent to petrol at 7·9d. per gallon, instead of 1s. 4d. to 1s. 6d. (1938.) In the case of a 20 h.p. motor vehicle converted to run on gas, the comparative results were 12 m.p.g on petrol and 21 cu. ft. on coal gas.

Taking petrol at 1s. 4d. per gallon and compressed gas at 2s. 6d. per 1,000 cu. ft., this is equivalent to 1·33d. per mile on petrol and 0·63d. per mile on gas, i.e., less than one-half the cost per mile. The results of similar tests by other authorities also emphasise the low-running costs of gas-operated petrol engine vehicles.

Using Coal Gas in Petrol Engines.—The heating value of ordinary coal gas—which is usually a mixture of hydrogen, methane, carbon-monoxide, unsaturated hydrocarbons and nitrogen—varies from about 450 to 550 B.T.U.'s per cu. ft.; the higher value corresponds to gases having a greater proportion of hydrogen.

The amount of air required for the combustion of coal gas varies from 5 to 8 volumes per unit volume of gas. The richer mixture gives the higher power output, whilst the weaker one gives the greater fuel economy for a given power output.

When using coal gas in petrol engines, the ordinary petrol carburettor is dispensed with—or it may be retained for starting purposes—a simple form of gas and air mixing device being substituted, since both the coal gas and air follow the same laws of gas flow.

The recommended arrangement for using gas in petrol engines, giving the highest power outputs combined with economy in gas consumption is to employ an air admission port of the fixed area, or non-variable type, leaving the gas supply to be controlled positively right down to the "stop" or "idling" position.

In the case of a 30 h.p. engine, a gas supply pipe of 1¼ in. bore has been found, on test, to give the best results, where the adjustable end of the gas pipe is introduced centrally into a cone-shaped extension of the induction pipe intake, in place of the petrol carburettor.

It is important to fit the mixing chamber with some device—preferably of an automatic nature, operated by the engine suction—*to shut off the gas supply as soon as the engine stops.* All modern gas carburettors are fitted with such devices.

The mixing valve system mentioned in Chapter XI is applicable to gas carburettors; the valve in this case can be arranged to open under engine suction to admit both gas and air.

When compressed gas is used a suitable pressure-reduction valve must be fitted for giving a low-pressure gas supply to the engine; a gas pressure of 8 to 16 inches of water is generally provided for in the carburettor.

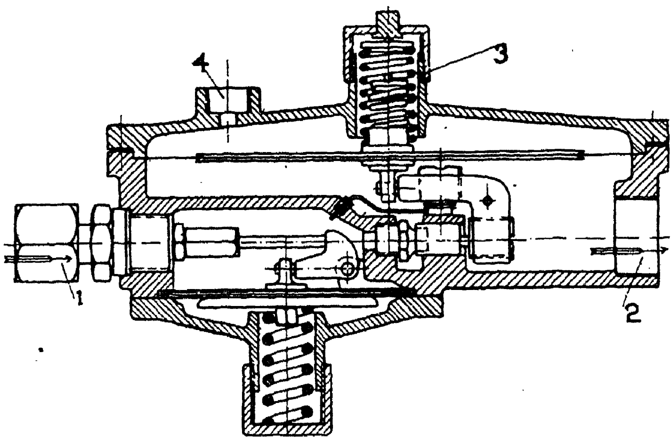


Fig. 142.—Coal Gas Pressure Reducing Valve.

Pressure Reducing Valve.—A typical pressure reducing valve is shown in Fig. 142. The gas inlet from the high pressure source is at 1 and the low pressure outlet at 2. Normally the high pressure gas flows through a small orifice into the low pressure chamber on the right. Any rise in pressure in the high pressure chamber causes the spring loaded diaphragm to deflect downwards and thus to shut off the gas supply. The low pressure regulator is shown at 3 and the orifice for a safety valve at 4. The low pressure chamber contains a sensitive diaphragm which protects the valve unit from the effects of a back fire. The con-

nections from the reducing valve to the engine are shown in Fig. 143. A two-way connection at the reducing valve takes the main gas supply from E to the gas mixing jet A, arranged in a venturi F, formed by the choke B. A smaller tube from D takes a reduced supply of gas direct to the inlet pipe, above the throttle, for engine idling purposes. An adjustment is provided at C for moving the outlet of the gas supply tube A

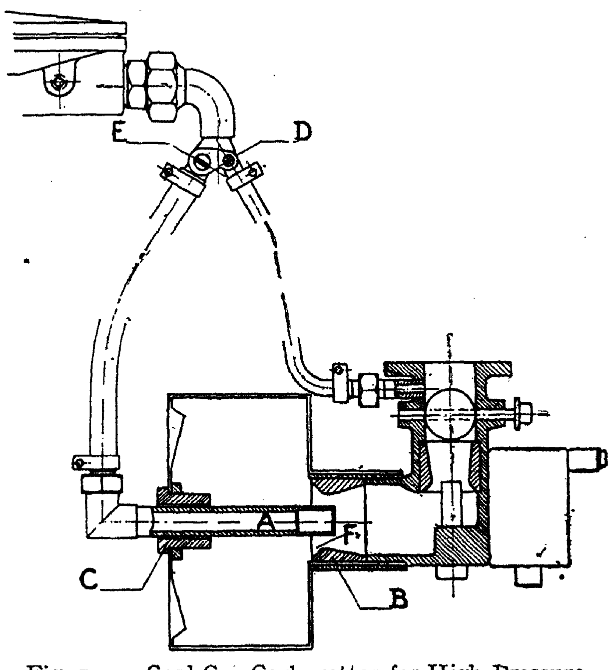


Fig. 143.—Coal Gas Carburettor for High Pressure Gas Supply System.

relatively to the venturi F in order to regulate the mixture strength. When moved from the position shown, to the left, the mixture is weakened.

Fig. 144 shows a typical compressed gas installation for a motor vehicle. Four high pressure steel cylinders 1 are connected together by suitable piping and unions 2; the left-hand cylinder union has a pipe connected to the cylinder gas charging valve 3. The high pressure supply is taken from the right-hand side

to a shut-off and control valve 4 to which is connected a high pressure gauge 5. When the valve 4 is opened high pressure gas is led to the high pressure side 6 of a pressure reducing valve unit 7 (shown in Fig. 142). The low pressure supply from this is taken to the gas carburettor 10, which is attached to the main air inlet of the petrol carburettor 9. The exhaust pipe of the engine is indicated at 8.

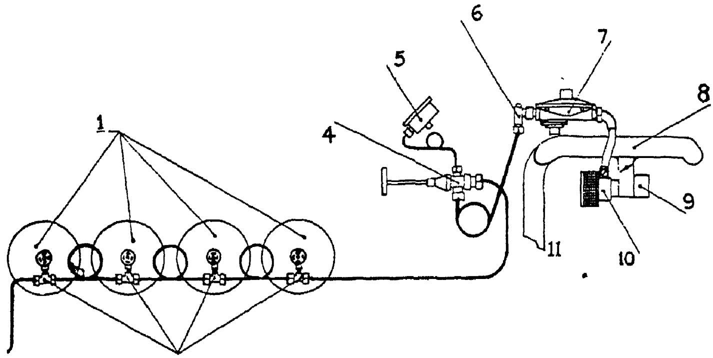


Fig. 144.—High Pressure Gas Installation for Motor Vehicle Engine.

Gas Cylinders.—The cylinders employed for high pressure coal gas installations in this country are usually made of Vickers-Armstrong Vibrac nickel-chromium-molybdenium steel, a typical cylinder measuring 7 ft. 8½ in. long by 10 in. outside diameter. It contains 715 cu. ft. of gas at 3,000 lbs. per sq. in. pressure and weighs 240 lbs.; a smaller cylinder 6 ft. 2 in. by 8 in. diameter of 359 cu. ft. capacity, weighing 124 lbs. is also made. The maximum working stress in the cylinder walls is 25 tons per sq. in.

Typical Gas Carburettors.—Fig. 145 illustrates a type of gas carburettor employed for motor-vehicle engines. This is fitted with a main jet (M); it has a choke and throttle valve of the conventional pattern. The air supply is controlled by means of the butterfly valve (H). The gas is admitted at (V), filling the chamber below the diaphragm (F) and escaping through the restricted passage (G) to the upper side

of (F). As soon as the engine is turned over the suction communicated through passage (D), pulls down the diaphragm (B), opening pilot valve (C) and causing a partial vacuum above (F). Due to the unequal pressure, diaphragm (F) rises, opening the

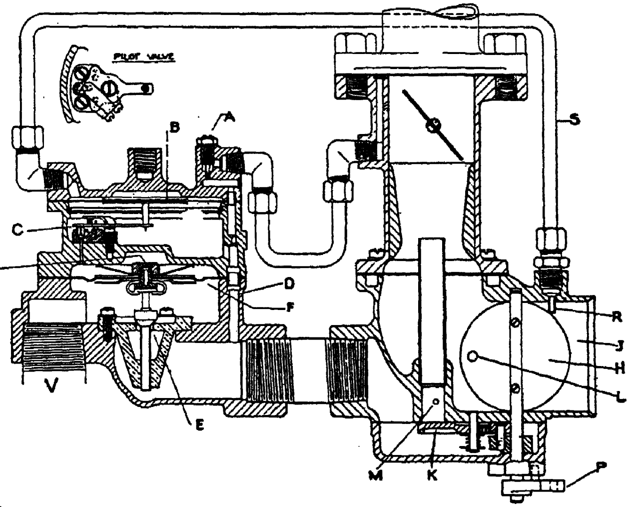


Fig. 145.—Gas carburettor used on Commercial Vehicles.

main fuel supply valve (E) and admitting gas to the carburettor, where it enters the air stream through the main fuel passage (K), which is adjustable. For idling, gas is fed above the throttle and is controlled by the adjusting needle (A).

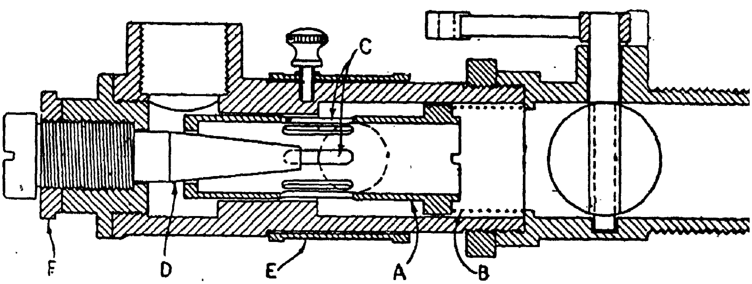


Fig. 146.—Gas Carburettor of the Gas, Light and Coal Company.

Fig. 146 illustrates a coal-gas carburettor devised by the Gas, Light and Coke Company, London. The

method of operation is as follows:—Suction of the engine draws the piston *A* against the spring *B* so that air enters through the slots *C* and coal gas through the annular space between the cone *D* and the piston. The air and gas mixture in the proportion of 5 to 8 parts of the former to 1 part of the latter then enter the

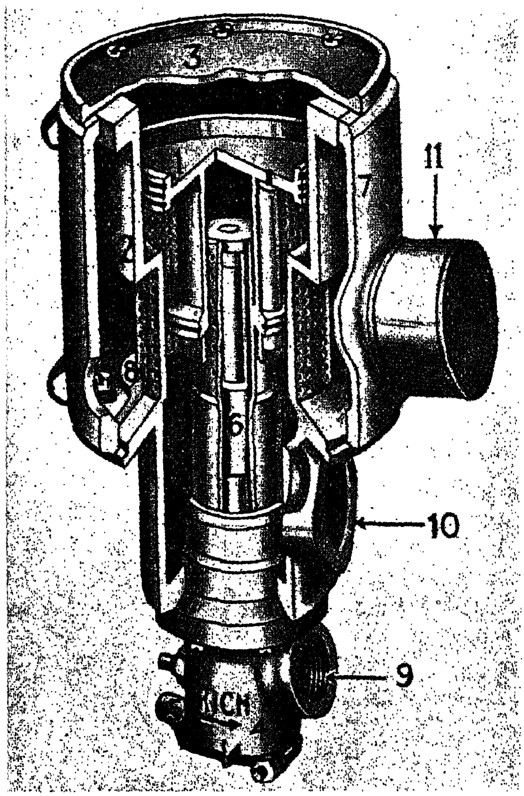


Fig. 147.—Another design of Gas Carburettor.

engine through the butterfly throttle shown on the right. The angle of the cone *D* is 6°, but for weaker gas to air mixtures a 4° cone is used; for richer mixtures the angle should be 8°.

In order to obtain a finer adjustment of the mixture strength a rotary type of air shutter *E* is provided to

open or close the air supply to the slotted holes in the piston *A*. The gas control cone *D* is provided with a parallel portion near the threaded part for giving idle running mixture; it is locked in position by the nut *F*.

Another design of gas carburettor is shown in Fig. 147; this belongs to the mixing valve class, and has a device for altering the ratio of air to gas to suit different gas compositions; it is known as the Superior-Otto instrument.

Referring to Fig. 147, the mixture adjustment is shown at (5), on the lower left side. This mixing valve is connected to the intake manifold at (10), the air enters at (11), and the gas connection from the regulator is at (9). In operation the air float (1) automatically rises and falls according to the speed and load of the engine, and as this float moves up and down it opens and closes both the gas and air ports, maintaining a uniform mixture ratio. When the engine stops the weight of the air float brings it down to the shoulder on the gas tube, automatically shutting off the gas. A butterfly throttle valve controls the engine speed.

A metering device of totally different design employs a single plug type gas valve and two balanced air valves interconnected and operated together by the governor in such a way that a uniform mixture is maintained from no load to full load. An adjustable fulcrum is provided on the top lever to give any desired air-gas ratio, and once this adjustment is set to give the best economy it need not be changed. In addition to this regulating valve a fuel mixer is provided which resembles a wagon wheel with the hub removed, the spokes being brass tubes with one end closed, the other end opening into the hollow rim through which the gas is fed. When the engine is running the air passes up between the spokes, while the gas escapes through saw slots cut axially in the spokes, resulting in a thorough mixing of the fuel and air.

Fig. 148* shows, in sectional view, a successful type of gas mixing valve developed by a French engineer

* Commercial Motor.

M. A. Pignot, for motor vehicles employing compressed gas.

It consists of a cylindrical mixing chamber with a cover held in place by a stirrup and screw device. The mixing valve has stems, working in guides, both above and below. The gas supply enters from below and the air through the apertures in the cylinder. The gas supply is regulated by means of the throttle shown, this being linked up to the driver's accelerator pedal.

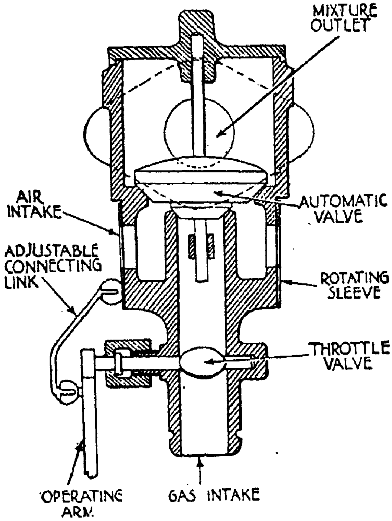


Fig. 148. Gas Mixing Valve.

The air intake has an adjustable concentric sleeve which is interconnected with the throttle so as to open and close with the latter. The sleeve in question has four holes corresponding with four diametrically-opposed air ports in the tube, the apertures being triangular. The air apertures are covered with wire gauze in order to reduce the air velocity.

The mixture strength, in this gas carburettor, can be varied by altering the length of the connecting link between the throttle and the air sleeve.

The carburettor described has given satisfactory results on heavy motor vehicles adapted by the Paris Gas Company.

Power Output on Gas.—Although there is not much reliable data available on this subject sufficient is known about the performance of petrol engines converted to run on coal gas to be able to draw certain conclusions.

According to the Report of a Government Committee on the use of gas in motor vehicles if the power output of an ordinary petrol engine is represented by 100, then when operating upon coal gas of 450 B.T.U.'s per cu. ft. the output is 91; it is assumed that with the exception of the carburettor the petrol engine is unaltered in any other way.

Dr. C. M. Walter of the Birmingham Gas Department carried out a series of researches on petrol engines of the commercial vehicle type using coal gas supplied from compressed gas cylinders. The tests were made upon engines fitted with gas mixing chambers, based upon the venturi flow system, whereby the gas entered around the venturi tube around which the main air supply flowed. The gas was controlled by a butterfly throttle and the air by means of a slotted plate.

The results for a supercharged 7 H.P. engine using petrol showed an output of 24·8 B.H.P. at 3,250 r.p.m. (maximum) with a brake thermal efficiency of 16·15 per cent. For town gas the maximum output was 17·9 B.H.P. at 2,846 r.p.m. (maximum) with a thermal efficiency of 19·35 per cent.

It will be seen that the power output and maximum speed are less than with petrol, but the efficiency—upon which the fuel or gas consumption depends—is much higher; the relative fuel consumption is therefore lower. By the use of higher compressions than the 5 to 1 ratio used the power output using gas can be progressively increased. Another method of increasing the output is to mix benzene vapour with the coal gas; the improvement thus obtained increases with the proportion of benzene vapour.

More recently gas engines have been operating with high compression ratios, similar to those used in compression-ignition engines.* In order to ignite the

* Described in "Automobile Engines." A. W. Judge. 4th Edition.

air-gas mixture a small amount of Diesel fuel oil is injected at very nearly the end of the compression stroke. High thermal efficiencies with low fuel consumptions and relatively high outputs per unit volume.

Other Gases Used in Petrol Type Engines.—Any other combustible hydrocarbon gas or mixture of gases can generally be employed with satisfactory results in internal combustion engines of the spark ignition type. Among the gases that are being used for this purpose are (1) Producer gas. (2) Methane. (3) Butane. (4) Natural gas.

Producer Gas.—In recent times, owing to the limited supply and high cost of petrol, commercial motor vehicles have been adapted to operate upon the combustible gases produced by drawing air through practically incandescent solid fuels such as anthracite, wood, charcoal, coke (low temperature), coal briquettes, peat coke, etc. The resultant gas is a mixture principally of carbon monoxide (CO) and nitrogen, but in some types of gas producer water is admitted to the heated fuel with the result that hydrogen and some methane (CH_4) is generated in addition to the carbon monoxide; small amounts of the incombustible carbon dioxide (CO_2) are usually included in the gas mixture which is fed into the engine. The heating value of producer gas depends upon the type of fuel employed and on the design of gas producer. It usually varies between the limits of 140 and 170 B.T.U.'s per cu. ft. when made from anthracite, coal or coke, and is therefore about one-third to one-quarter the heating value of town or coal gas.

When *charcoal* is used as a fuel the heating value lies between about 110 and 140 B.T.U.'s per cu. ft. The consumption of charcoal is about 1 lb. per B.H.P. per hour.

For *wood* fuels the consumption is about 2·0 to 2·5 lb. per B.H.P. per hour. *Peat fuels* usually give consumptions of 0·9 to 1·2 lb. per B.H.P. per hour. *Anthracite* and similar coal fuels give consumptions of 0·9 to 1·3 lbs. per B.H.P. per hour. In this connection it is of interest to note that 12 to 14 lbs. of such fuels are equivalent to one gallon of petrol.

Methane (CH_4).—This hydrocarbon gas has a high heating value, owing to its high carbon content. The heating or calorific value is 23,500 B.T.U.'s per lb. or 1,066 B.T.U.'s per cu. ft. at 32° Fah. and normal atmospheric pressure. This is the higher heating value as it includes the latent heat of the steam formed during combustion. The lower heating value is 22,534 B.T.U.'s per lb.

Compressed methane or the liquefied gas has been used for motor vehicle engines, chiefly in Continental countries. Methane forms one of the principal constituents of fire-damp, coke-oven and natural gas.

In regard to the liquefaction of methane it has been estimated that this costs rather less than 3d. per gallon and that 100 cu. ft. of the gas will produce one gallon of liquid.

Butane.—This hydrocarbon gas has the chemical symbol $C_4 H_{10}$ and belongs to the paraffin series of hydrocarbons. It has a heating value of about 21,000 B.T.U.'s per lb. (lower value). The compressed or liquefied gas has been used for motor vehicle engines on the Continent.

Natural Gas.—Combustible gaseous mixtures are obtained from deep drillings in the earth in certain countries. Thus in this country large supplies are available. A drilling at Dalkeith, near Edinburgh, produced upwards of two million cubic feet per day.* The gas in question contained 80·5 per cent. methane; 19·5 per cent. ethane, 1·3 per cent. hydrogen and minute amounts of carbon dioxide and carbon monoxide.

The heating value of the gas was 1,140 B.T.U.'s per cu. ft.

Natural gas occurs plentifully in certain parts of the U.S.A. where there was a pipe line distribution, in 1938, of more than 150,000 miles. The gas has a calorific value of 750 to 950 B.T.U.'s per cu. ft.

Sewage Works Gas.—The collected gases from sewage works in this country contain a large percentage

* Interim Report of Tractor Gas Committee, 1940.

of methane. Thus in the London area an analysis of the washed gases gave the following composition:—Methane, 95 per cent.; carbon dioxide, 4 per cent.; other gases 1 per cent. The production of methane from four London sewage works in 1939 amounted to over a million cu. ft. per day, equivalent to about 1,100 gallons of petrol per day. If this gas were supplied in compressd or liquefied form it would afford a useful source of fuel for motor vehicles.

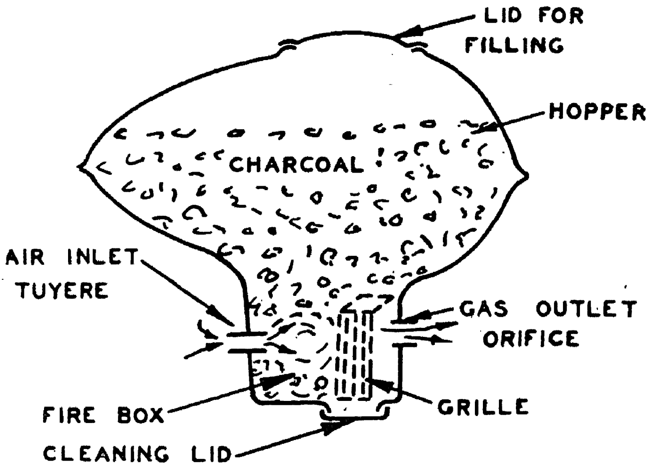


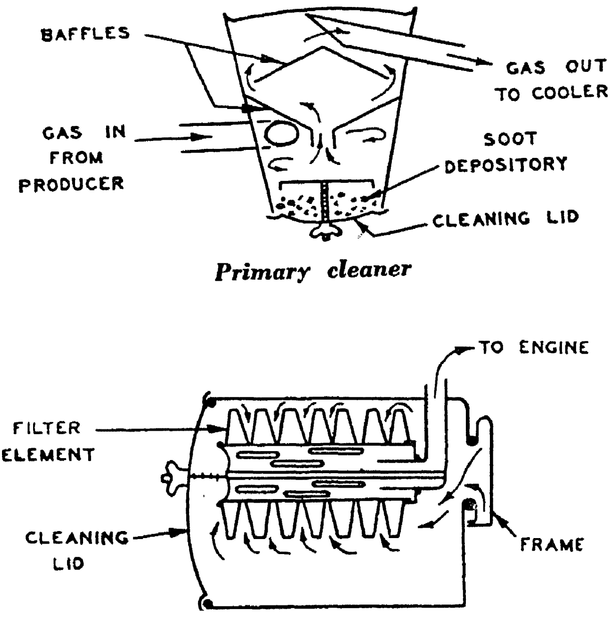
Fig. 149.—A Charcoal Producer Gas Plant.

Principle of Producer Gas Plant.—To illustrate the principle of the producer gas plant the simple example of a charcoal fuel gas producer (Fig. 149)* has been chosen. Such a producer has been employed in trailer form for Swedish commercial vehicles.

The charcoal is contained in a generator of the shape illustrated and is built upon what is known as the cross-draught principle. Air at high velocity is drawn into the fire zone through a horizontal nozzle or tuyére located at the rear and about half-way up the side of the fire box. In passing through the hot combustion zone, the oxygen of the air combines with the carbon of the charcoal to form carbon monoxide, which is the chief fuel constituent of the gas produced. This gas passes through a grill-shielded orifice on the opposite

* Automotive Industries. January, 1940.

side from the air inlet and slightly lower than it. From there it passes successively through a primary cleaner located on the left, through the box-section frame members which serve as a cooler, through a secondary cleaner or filter, and finally into a flexible hose which is snap-coupled to the main pipe leading to the car engine. At the engine it passes through a mixing valve.



Primary cleaner

Secondary cleaner

Fig. 150.—Method of Cleaning the Producer Gas.

The hopper and fire box are welded together to form a unit. The egg-shaped hopper, superimposed upon the fire box, is made of 1-mm. sheet steel. No refractory lining is used. On top of the hopper and on the bottom of the fire box there are lids that serve for charging and cleaning respectively. The grill shielding the gas outlet is a stamping of perforated steel which is placed vertically about 2 in. ahead of the outlet orifice. It is demountable for quick replacement.

The air-inlet tuyére, which is water-cooled, comprises

an inner and an outer steel tube, the two being welded together co-axially. The annular space thus formed is the water jacket, into which inlet and outlet tubes are welded. Water from a flat rectangular tank bolted to the right side of the hopper is circulated through the jacket by thermo-siphon action.

The gas generated contains solid fuel particles which must be removed from it before use in the engine; otherwise excessive engine wear would occur. In order to clean the gas it is made to pass through two cleaners, namely, a primary and secondary cleaner.

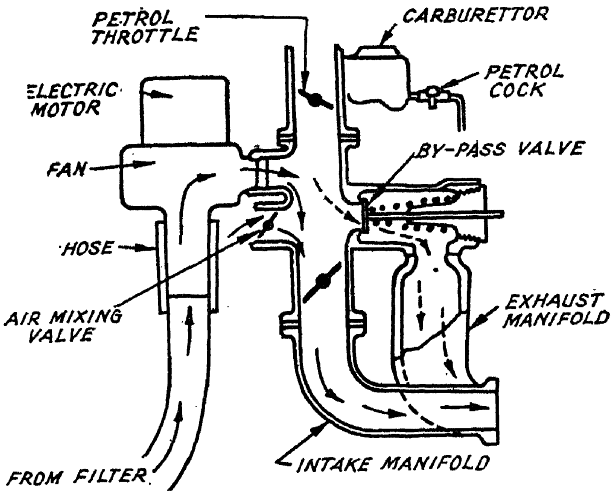


Fig. 151.— Air and Gas Mixing Arrangement for the Charcoal Producer Gas Plant.

The former (Fig. 150) gets rid of most of the larger deposits and the latter—which is of the felt filter element pattern—eliminates the finer particles. These filters are designed for quick cleaning purposes and it is necessary to remove the deposit every 200 to 300 miles of road operation.

From the secondary cleaner the gas enters the engine through a mixing valve (Fig. 151) which controls the air supply in proportion to the main throttle opening by means of a cam arrangement. If richer gas mixtures are required the air throttle can be closed to the desired extent by means of an independent hand control.

An electrically-operated suction fan, situated just ahead of the mixing valve, is fitted for cold starting purposes; the latter operation takes about five minutes.

Between the primary and secondary gas cleaners there is a large section metal duct which serves to cool the gas on its way to the engine. The principle of the charcoal gas producer described is the same as that employed in producers employing other fuels so that it is unnecessary here to describe such producers in detail.

General Notes on Motor Gas Producers.—In regard to the cost of fuel for producers employed on motor vehicles, owing to the fact that such fuels are tax-free in this country, whereas petrol and Diesel oil are subjected to a duty of 9d. per gallon (£9 per ton) and, further, as 15 lbs. of anthracite is equivalent, roughly, to one gallon of petrol, it is apparent that at, say, 60s. per ton, the cost of anthracite is equivalent to petrol of about 5d. per gallon as compared with petrol engine fuel costs of nearly 2s. per gallon (1941).

Some allowance, however, must be made for the fact that when Diesel oil is used as a fuel for compression-ignition engines, the thermal efficiency is higher than for producer gas used in petrol-type engines, so that the producer gas fuel then works out at the equivalent of 6½d. to 7½d. per gallon of Diesel oil.

In regard to *power output*, when used in petrol engines, this is about 25 to 30 per cent. less than when operating on petrol. The use of larger bore cylinders or of superchargers is necessary to make up for this power reduction when equivalent outputs are desired.

The producer gas plant requires efficient gas filtering methods since any solid particles, however fine, will cause increased cylinder and piston wear and may even find their way down into the main and big end bearings in the oil returned from the cylinder walls. Cases have occurred of certain motor vehicle engines adapted to run on producer gas, of excessive cylinder and bearing wear.

The principal disadvantages of gas producers, for motor vehicles, are those of weight, bulk and initial cost. In regard to weight, typical gas producer plant commercial vehicles exceeding about 2 tons unladen

weight, vary from 6 cwt. to 15 cwt. Thus in a particular make of producer the models for outputs of 60, 80 and 120 h.p. weighed 9, 11 and 15 cwt., respectively. It should be noted that this is additional weight to that of the original petrol engine vehicle and it therefore represents a reduction in the pay loads of the vehicles concerned. The bulk of the gas generator is such that additional space must be found on the vehicle for it. The usual form of generator is the cylindrical one with

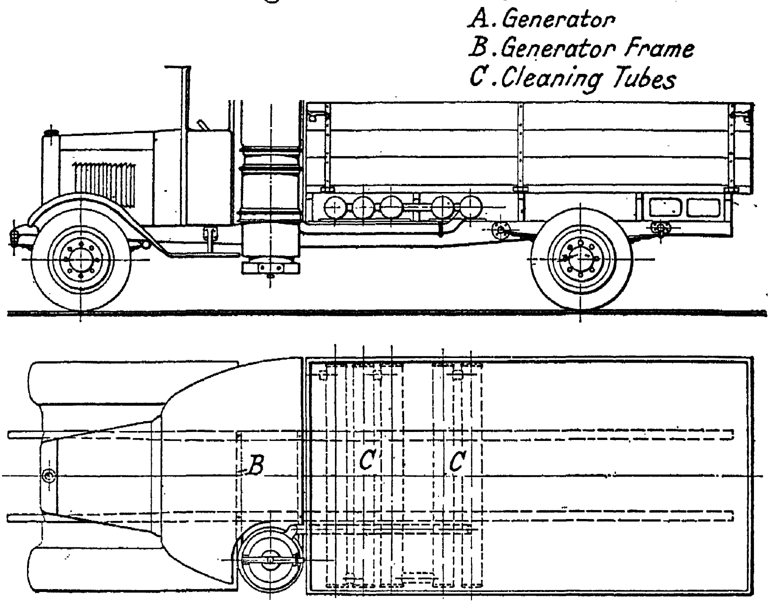


Fig. 152.—The Kromag Gas Producer Plant. A—Generator. B—Generator Frame. C—Gas Cleaning Tubes.

the axis vertical. The diameters of generators for 25, 50, 80 and 120 h.p. engines in a typical make of plant were 1 ft. 4 in., 1 ft. 8 in., 1 ft. 10 in. and 2 ft. 0 in., respectively, and the heights ranged from 4 ft. to 6 ft. The generator is usually accommodated on the side of the driver's cab or at the rear end of the vehicle; alternatively, it may be mounted on a trailer unit; in either of the former two positions it decreases the available body space. In this connection a neat method of stowage for the generator is that illustrated in Fig. 152, for the Kromag make of producer.

Typical Gas Producers for Motor Vehicles.—As a result of the growing demand for a reduction in fuel costs and due, also, to the reduced supplies of petrol during the war period, a number of different makes of gas producers, suitable for the conversion of petrol-engined vehicles, has been made available, commercially. Typical examples of such producers * are the High Speed Gas (H.S.G.), Brush Koela, Gohin, Dupuy, Parker, Bellay, etc. The principal types of gas producer are as follows: (1) *Up-draught.* (2) *Down-draught.* (3) *Cross-draught;* and (4) *Double-draught* and *Double-zone* ones.

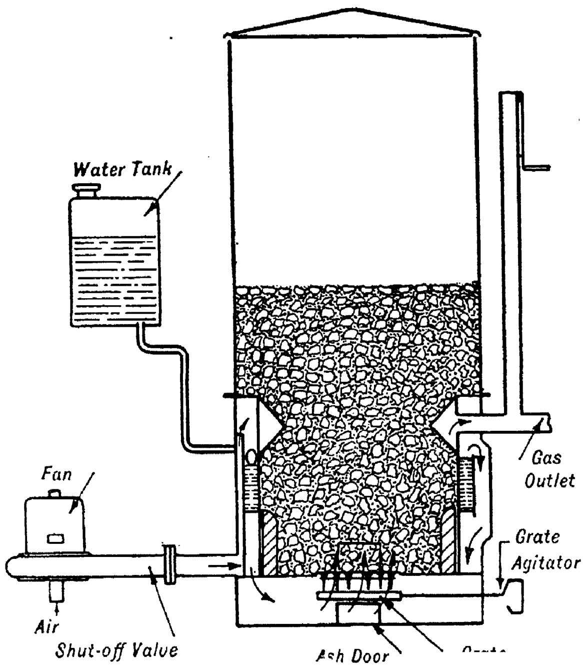


Fig. 153.—The Wisco Up-Draught Gas Producer

Typical examples of the *up-draught gas producer* are the Wisco (German) and the Koela, the former being shown, diagrammatically, in Fig. 153. In this example the gas and air flow vertically upwards and

* A good account of typical producers is given in a Paper read before the Institute of Fuel, December 8th, 1938, and reproduced in "The Engineer," December 23rd, 1938

therefore in the opposite direction to the flow or fall of the fuel. This arrangement gives excellent thermal results, the various zones of chemical reaction being layered horizontally. It has the disadvantage, however, of being unsuitable for fuels of a tarry nature since the volatile products of the tar are liable to reach the engine. The Wisco producer is intended to operate with charcoal, low temperature coke or anthracite. The lower part of the combustion space is lined with refractory material, whilst the upper part where the cross-section increases has a water jacket or boiler in which the level is kept constant by automatic means. The air is led into the lowest part of the fuel space, a fan being used for starting purposes. The air after passing through the lower part of the fuel bed is led off to the side and then upwards through the duct on the left Fig. 153) and thence through the water inside a pipe; it then passes round the producer picking up steam as it goes. This mixture of steam and air is next led down outside the producer into a space surrounding the fire-brick lined lower part of the combustion zone. There the steam and air are superheated before passing down into the ashpit and upwards through the grate; the latter can be agitated from outside.

In the Koela up-draught producer the air is led vertically downwards through a pipe which is jacketed by another through which the hot producer gas is led from the upper combustion zone downwards to the outlet. This serves to pre-heat the incoming air and at the same time to cool the outgoing gas. There is also a regulated water supply fed into the air inlet pipe so that it becomes vaporized by the hot gas in the surrounding jacket.

Fig. 154 illustrates the British Koela *down-draught producer*. This class of producer of which there are several Continental makes utilizes the principle of air and gas flow vertically downwards, i.e., in the same direction as the fuel flow. They give good results with wood charcoal, raw wood and tarry fuels; in the latter connection this type of producer prevents, to a large degree, tarry matter and dust from leaving with the generated gas. Water is not used to any extent with down-draught producers, but moisture-containing char-

coal will give good results. The Koela producer is similar in its general aspects to the up-draught producer of the same make. The air heating and gas cooling arrangement of the latter is, however, reversed. The water supply is fed into the top of the air inlet pipe in the opposite direction to the air flow.

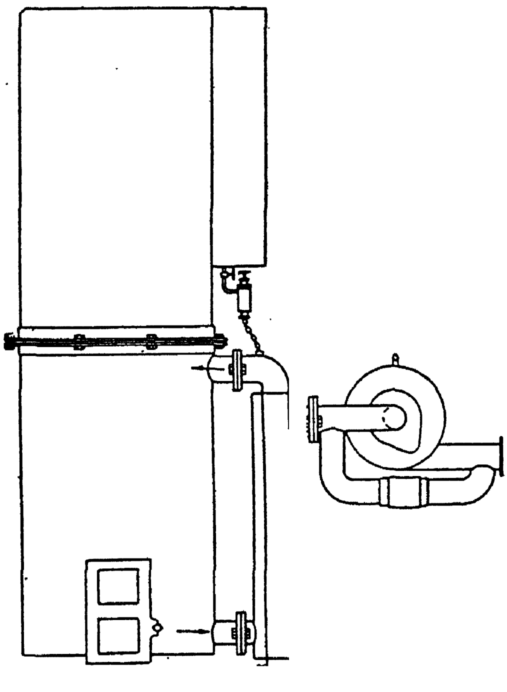


Fig. 154.—The Koela Down-Draught Gas Producer.

In the *cross-draught producer*, of which an example is given in Fig. 155, the air is drawn into the combustion zone through a horizontal pipe or tuyére and creates a very hot fire zone. The generated gas leaves by an orifice slightly higher than and diametrically opposite the tuyére; a grille is arranged to cover the exit orifice in order to prevent solid matter from accompanying the gas. The tuyére is usually made

of an inner copper and outer bronze fitting between which cooling water passes; this is very necessary since the tuyére end tends to burn away in time although it is made so as to be readily replaced.

The *double-draught producer* utilizes the principle of an upper part of a bed of fuel arranged to burn downwards, thus causing the volatile matter to be driven off,

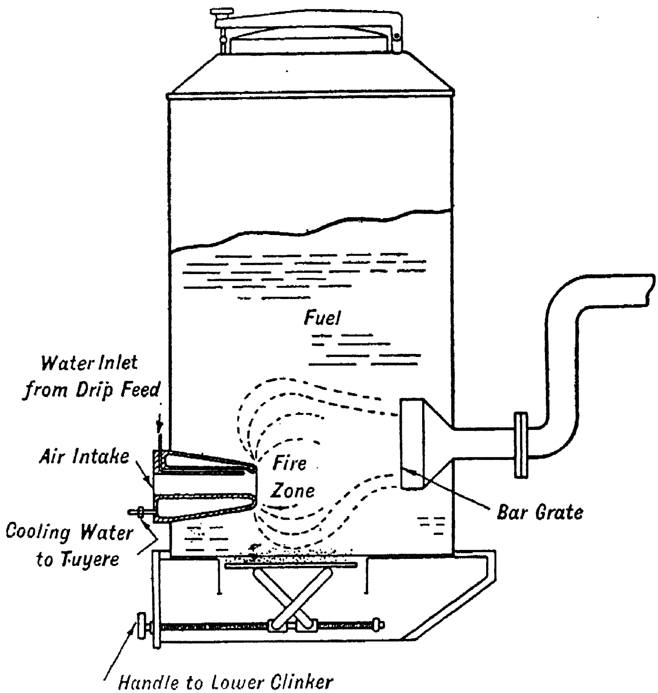


Fig. 155.—The H.S.G. Cross-Draught Gas Producer. [The Engineer.]

this matter then passing through the upper incandescent zone of the lower up-draught part of the fuel bed so as to be completely eliminated.

In the *double zone pattern producer* two fuel beds are often employed, these being arranged one within the other; separate fuel feeds are provided for each bed. The air supply may be downwards through the outer bed only and the hot gases pass upwards through the inner fuel zone; alternatively two air feeds may be

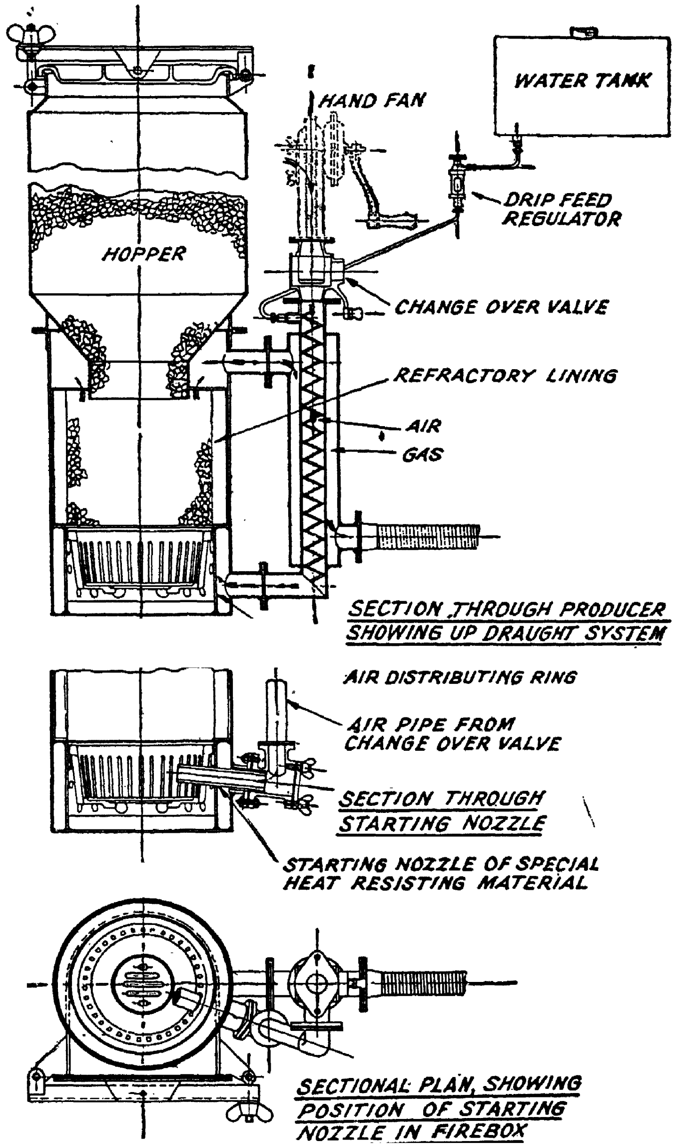


Fig. 156.—The Brush Koela Double-Draught Gas Producer.

arranged for. Similarly in the double draught type of producer the air flow may be arranged in two separate feeds, both of which are current-wise, with downward fuel flow.

Fig. 156 illustrates the Brush Koela double-draught producer which, it is claimed, combines the advantages of both the cross and up-draught systems. It provides quick starting by reason of the cross-draught system and the highly efficient combustion of the up-draught one. The air passes from the pre-heater upwards through the grate resulting in slow evenly distributed combustion. This is an advantage when mineral de-

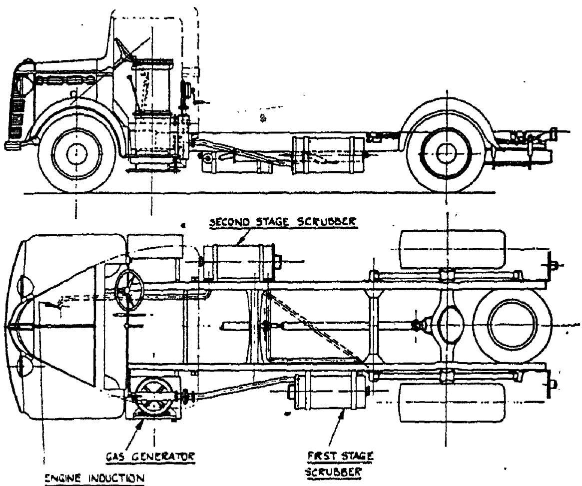


Fig. 157.—Showing Installation of Brush Koela Plant on Commercial Vehicle.

rived fuels are used as the temperatures can be controlled below the fusion point of the ash by means of superheated steam; some 15 to 20 per cent. of the fuel used is in the form of water.

The cross-draught system is used only for starting purposes. The draught air for starting may be supplied from the engine suction if the engine is started on petrol; alternatively, a simple blower is used to supply the air. A two-way valve is employed to enable an easy change over to be made from cross to up-draught. When the engine is started on petrol it can

be switched over so as to run on producer gas in 1 to 1½ minutes.

The producer illustrated in Fig. 156 uses fuel which works out at the equivalent of petrol at 4½d. to 5d. per gallon.

Two scrubbers or cleaners are employed to clean and cool the gas before it reaches the engine. These are usually arranged horizontally under the body, parallel to the frame of the vehicle. Fig. 157 shows a typical Koela double-draught gas producer installation as fitted to a Bedford 3-ton vehicle of the semi-forward control pattern. The No. 2 size of producer holds 40 to 70 lbs. of fuel—according to the type of fuel used—and one filling lasts from 40 to 70 miles.

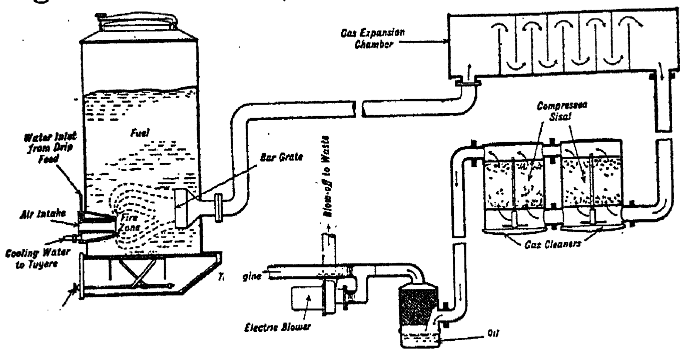


Fig. 158.—The High Speed Gas Company's Commercial Vehicle Gas Producer System.

In connection with the maintenance of producer gas vehicles of the type illustrated in Fig. 156, apart from replenishing the fuel hopper it is necessary only to clean the grate and dust filter periodically.

The Complete Producer Plant.—The gas producer plant consists of the gas generator with its fuel hopper, air supply and, in some designs, water supply tank and regulator. The gas from the generator is usually first cooled and then cleaned, by leading it through a cooler having a relatively large area cooling vessel made of sheet metal and provided with baffles to assist in the deposition of some of the larger solid matter. It then passes through a coarse cleaner or filter and

finally through a fine filter which removes the smallest dust particles. Thence, the cleaned cool gas is led to the induction manifold of the engine through the gas mixing device or gas carburettor which is provided with an adjustable air supply and butterfly throttle control for the amount of gas passing into the induction manifold.

The gas carburettor is similar to that employed for coal gas.

Fig. 158 illustrates the complete producer plant of the H.S.G. system used in this country; the generator for this plant is the same as that illustrated in Fig. 155. The fire zone is of "tulip" shape in front of the cross-draught system tuyére and carbon monoxide is formed in the outer zone of this space. Water for the production of hydrogen and methane is introduced from the tuyére at the tip of the air blast and is so arranged as to limit the space in which combustion occurs so that it cannot spread through the mixture.

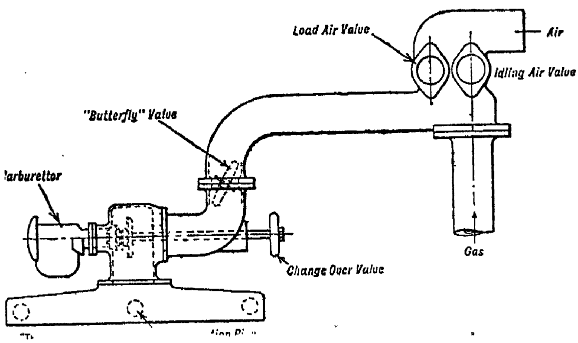


Fig. 159.—The Producer Gas Connections to the Engine Induction Manifold.

The generated gas is led from the bell-mouthed pipe in the generator to a gas expansion chamber, where it is cooled. It then passes through a scrubber chamber where most of the solid matter is deposited; sisal grass tow is employed for this purpose. Finally, the gas is passed through the second cleaner which contains oil-soaked fibrous material. Between this cleaner and the gas mixing valve is an electric suction fan which is fitted to one branch of a two-way pipe, for starting purposes.

Fig. 159 illustrates the gas connections to the petrol-

type engine in one of the alternative arrangements that are used. The gas enters the pipe shown on the right and then passes two barrel type air inlet valves before passing on to the engine throttle control and thence into the inlet manifold. The main air valve is connected to and operated by the throttle mechanism in order to give the correct amount of air for each

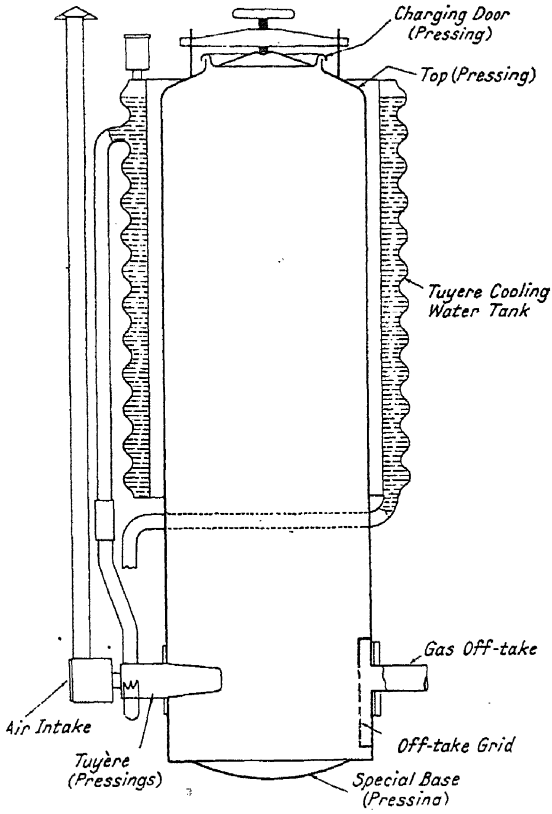


Fig. 160. Official Design of Gas Producer. [Crown Copyright.]

position of the throttle. The valve has also an auxiliary control for altering the amount of air at the driver's discretion so as to obtain the best running results. The other valve is fitted for engine idling purposes.

For starting purposes there is a wick which is arranged in the external end of the tuyére and is fed with paraffin by gravity from a dashboard tank. Upon

lighting the wick and switching on the electric fan combustion commences and in about 3 to 5 minutes the engine can be started with its electric starting motor.

Official Design of Trailer Gas Producer Unit.—In 1940 a Committee, which was first set up in May, 1937, by the Mines Department, issued a Report on the Emergency Conversion of Motor Vehicles to Producer Gas. This Report * contained many useful suggestions and included particulars and illustrations of an emergency gas producer of the cross-draught pattern suitable for use as a trailer unit. The producer was

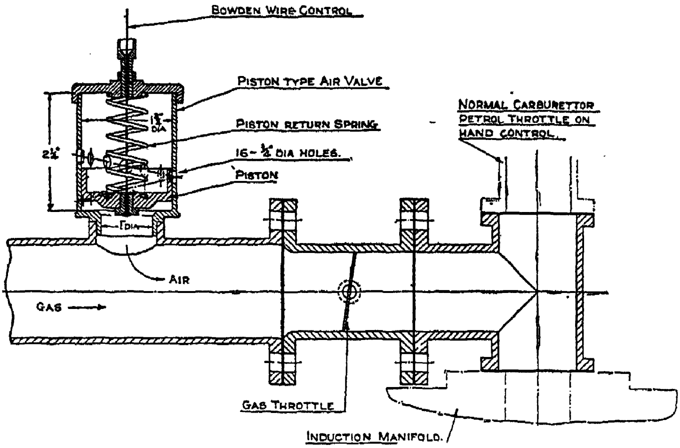


Fig. 161.—Official Design of Gas Mixing and Petrol Gas Conversion Unit. [Crown Copyright.]

of cylindrical form with the axis vertical and the upper part of the cylinder was surrounded by a corrugated sheet metal water tank for cooling purposes. The cylindrical shell was 1 ft. 6in. in diameter and 4ft. 6in. high. The complete plant was designed for sheet steel construction and the number of parts reduced to a minimum for cheapness and ease of rapid production. The original report should be consulted for constructional and operational details.

A sectional view of the gas generator is given in Fig. 160, whilst details of the gas mixing and petrol-gas conversion controls are reproduced in Fig. 161.

* Report of the Committee on The Emergency Conversion of Motor Vehicles to Producer Gas. H.M. Stationery Office, Kingsway. London, W.C.2. (9d.).

CHAPTER IX

HIGH ALTITUDE AND AIRCRAFT CARBURETTORS

Carburettors for High Altitudes.—It has already been stated that the effect of reducing the density of the air taken through the carburettor is to cause a corresponding enrichment of the mixture. In the case of aircraft engines, therefore, means have to be provided for keeping the mixture strength about constant as the altitude increases (and the air density

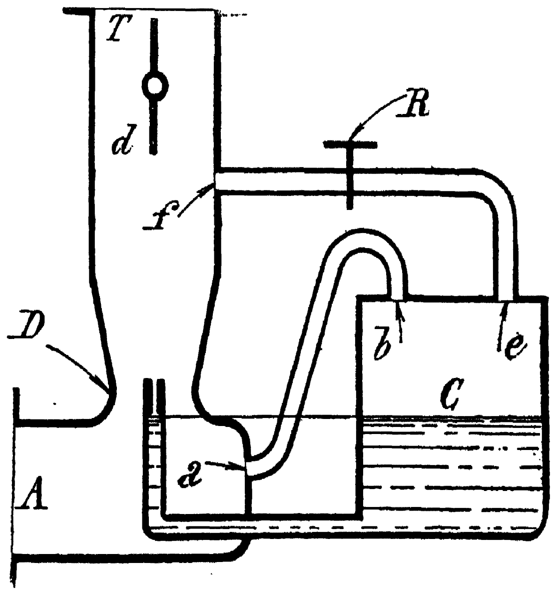


Fig. 162.—Illustrating the Zenith Altitude Control Method.

decreases). The temperature of the air also falls as the height increases, and this tends to increase the quantity of the air drawn in. The density diminution, however, considerably outweighs this effect. In order to compensate for the enrichment effect, several devices have been produced by manufacturers or aircraft carburettors.

Fig. 162 illustrates schematically, the principle of a typical aircraft carburettor. Here the float chamber, unlike that of automobile carburettors, is hermetically sealed, and is provided with a pipe *e*, fitted with tap R communicating with the mixture chamber *f* of the carburettor. There is also a second pipe *ab* which communicates with the air inlet side. For ordinary ground and low altitude running the tap R is closed and the pressure in the float chamber is atmospheric, through the pipe *ab*. At higher altitudes R is opened

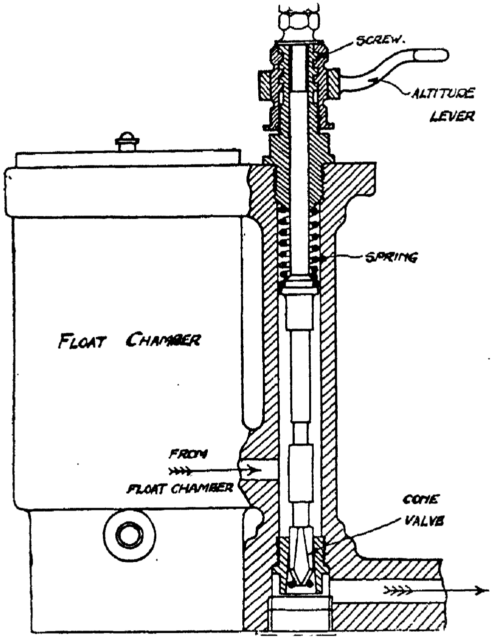


Fig. 163.—A Typical Altitude Control.

by the pilot and the partial vacuum existing in the chamber *d* is communicated in part to the float chamber; this reduces the "head" or pressure difference, tending to cause the fuel to flow from the jet—in other words, it tends to draw part of the fuel in the jet back again into the float chamber, and so reduces the mixture strength. The degree of opening of the tap R determines the amount of impoverishing and usually is controlled by a lever working in a sector graduated with the altitude.

Fig. 163 shows a part section of the carburettor that has been used on certain Rolls Royce aircraft engines. In this case the fuel has to flow from the float chamber to the jet past a cone valve, the effective area of the passage between which, and the metal plug shown can be varied by means of the altitude lever. The latter in rotating screws down the valve and diminishes the supply of fuel, thus reducing the (enrichened) mixture strength.

Fig. 164 illustrates the principles of another type of altitude control used on aircraft carburettors. The sketch shows diagrammatically, an air-bleed* type of carburettor having a main metering jet A, upon which the carburettor operates normally. The altitude needle

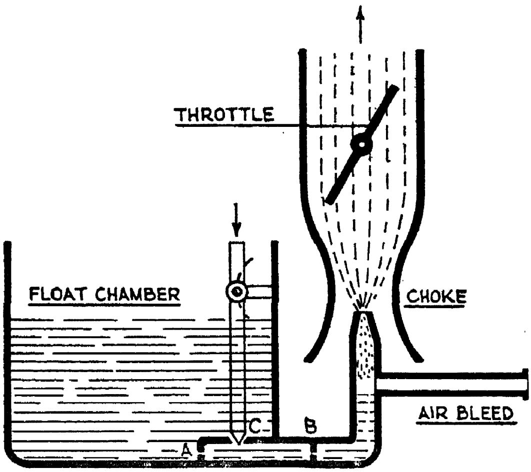


Fig. 164.—Illustrating Principle of an Aircraft Carburettor.

valve C is then kept in the lifted position so that its orifice is fully open. As the altitude increases the needle C is lowered on to its seating, gradually, so that finally the main jet of the carburettor is now supplied by both the metering jets A and B and the petrol supply is thereby reduced, since B is appreciably smaller than the needle valve seating orifice. In effect the progressive lowering of the needle valve is equivalent to a gradual reduction of the main jet area.

*In practice the air bleed opening to the atmosphere would be above the petrol level in float chamber.

In another system of altitude control the size of the main jet is controlled by a tapered needle which dips into the jet in a somewhat similar manner to that of the S.U. car carburettor. The needle is connected by suitable mechanism to an aneroid bellows (or exhausted thin metal corrugated box). As the altitude increases the altitude bellows expands and its movement is arranged to move the needle further into the jet orifice so as to reduce the effective area of the latter.

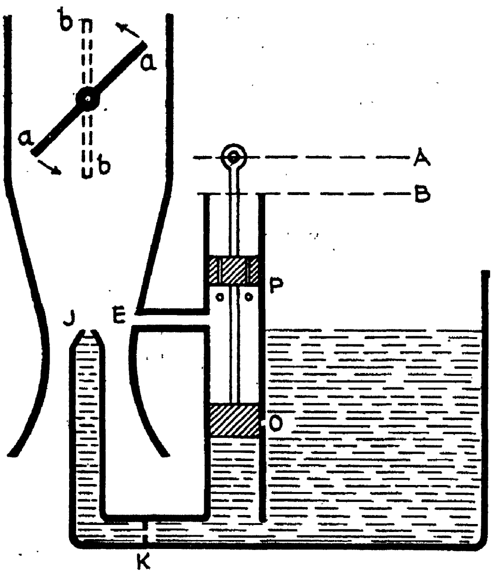


Fig. 165.—Mixture Enrichment Device.

A method used for aircraft carburettor enrichment is illustrated, diagrammatically, in Fig. 165. Apart from the main jet J with its fuel metering orifice K, there is a small vertical cylinder, on the side of the float chamber, having a hole O in the float chamber side and a small passage communicating with the choke tube at E. Air holes P are also provided in the upper end of this cylinder. When the engine is operating at low altitudes or under cruising conditions on an "economical" or weaker mixture the throttle is in the position *aa* and the top of the piston rod is at the level A. It will be observed that there are two

pistons, the lower one of which covers the petrol orifice O and the upper one uncovers the air holes P. Under these circumstances a small quantity of air passes through these holes and into the main carburettor passage, through E. When the throttle is fully opened to the dotted position *bb* the throttle mechanism moves the piston rod top to the position B so as to close the air holes and open the petrol hole O so as to admit petrol to the choke tube through the passage E and thus enrich the main mixture.

Fig. 166 illustrates a patented altitude control device for uniform mixture control operating on this principle.

There is a normal float chamber A with its needle valve B. C C are the petrol jets, and D D the choke tubes. The petrol vapour is introduced into the choke tubes by the pipes E E leading from diffuser chambers F F. In each of these chambers there is a long needle valve G—shown in right hand illustration—which controls the inflow of air through the

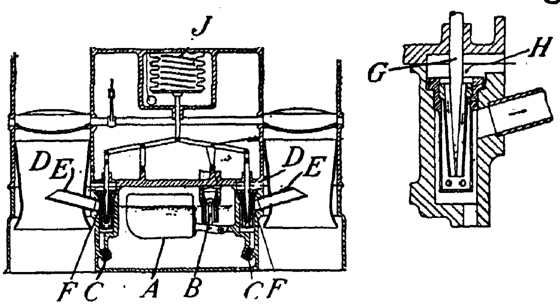


Fig. 166.—Another Aircraft Carburettor Scheme.

passage H. These needles are controlled by the aneroid bellows J and adjust the suction on the petrol jets C according to the altitude of the machine.

Requirements of Aircraft Carburettors.—Apart from the necessity of a reliable method of compensating the mixture for altitude enrichment effect, the carburettor must have the usual mixture strength maintenance device over the engine speed range, i.e., it must compensate for the mixture enrichment with increase in engine speed of the simple jet and choke tube arrangement.

The carburettor should also be provided with a satisfactory cold starting device and an acceleration pump, as for automobile types.

It is further necessary for the aircraft carburettor to operate on a mixture from 15 to 20 per cent. richer in petrol than the correct mixture for complete combustion, in order to obtain its full power on open throttle. For normal cruising purposes a control should be provided so that the carburettor will supply a mixture about 15 per cent. weaker in fuel than the correct one. This mixture is used for outputs of 50 to 80 per cent. of the maximum value.

In the case of supercharged engines in which the pressure of the air in the inlet manifold is greater than atmospheric another carburettor throttle control is necessary to prevent the engine from developing its full "rated" power at altitude below the rated one.*

The desirable characteristics of aircraft carburettors may briefly be summarized as follows:—

They are completely pressure balanced, and the range of mixture control for altitude is enough to meet all requirements up to at least 30,000 ft., but for use in machines unlikely to attain great altitudes, the percentage of altitude control is cut down to about 20 per cent.

This demand for a great range of altitude control calls for extreme care in design and a special altitude control system, in order to avoid any suddenness of action, and to ensure that equal increment of movement of the altitude control lever shall give equal and progressive weakening of the mixture, as previously stated.

Further, it is essential for convenience in flying, that for a given position of the altitude control lever, the mixture shall be weakened by the same percentage at all throttle positions. The pilot will then only have to alter the position of his altitude control lever with change of altitude, and not for different throttle positions at the same height.

* An account of aircraft carburettors in theory and practice is given in "Aircraft Engines," Vol. I., A. W. Judge. (Chapman and Hall, Ltd.).

Because of the amount of altitude control required at great heights, it is imperative that there shall be an interlocking gear, which will shut the altitude control valve when the throttle is closed for a dive, to ensure that the engine will open up again. On engines which are likely to cruise at altitudes at part throttle for long periods, it is necessary for fuel economy that the interlocking gear does not begin to close the altitude control before the half throttle position, and the differential linkage and lost motion device on the Claudel-Hobson carburettor is designed with this end in view. In some cases the interlocking gear is arranged on the engine or machine instead of on the carburettor.

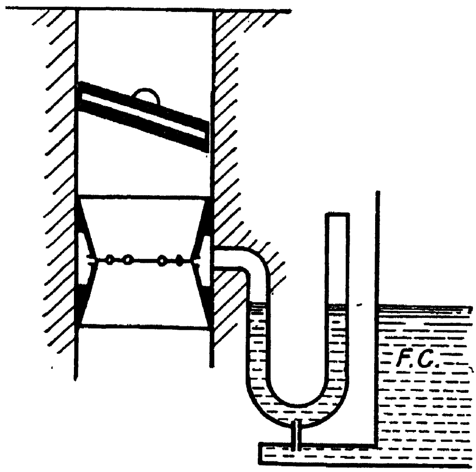


Fig. 167.

The butterfly throttle now used in the Claudel-Hobson carburettor is quite new in principle, and is not only the throttle, but is definitely part of the slow-running system.

A form of float gear to give great capacity with a given size of float chamber should also be used.

A Typical Aircraft Carburettor.—The Claudel-Hobson* aircraft carburettor, which we have selected as a typical example of one widely used on British aeroplanes, embodies in its design these features.

It employs a diffuser using a progressively emptied fuel-well with air bleed; the power-jet principle which gives maximum power at full throttle with economical running at part throttle; a new type of butterfly throttle of the hollow vane pattern, forming part of the slow-running system and a form of float gear to give great capacity with a given size of float chamber.

The principle of the carburettor is illustrated in Figs. 167 to 169.

In Fig. 167, a "U" tube is shown filled with petrol through the metering jet below, up to a constant level as maintained by the float chamber. The hollow throttle is closed, the pressure on the exit of the "U" tube is atmospheric and it is balanced by the air pressure on the other limb of the "U" tube; the petrol is at the same height in both limbs.

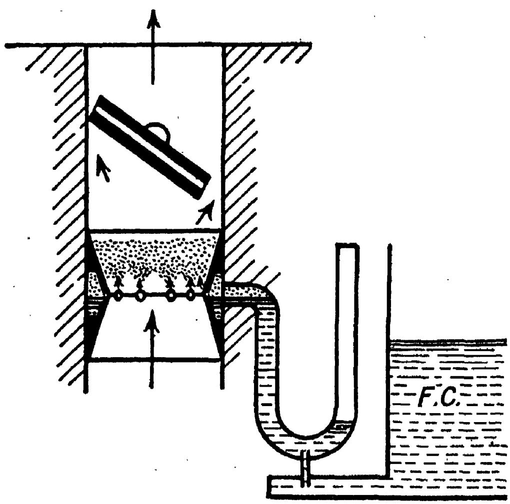


Fig. 168.

In Fig. 168 the throttle is partly open and air passing through the choke; consequently the pressure in the choke is less than atmosphere, while the free end of the "U" tube remains at atmospheric pressure; therefore the fuel in the "U" tube will be driven out into the choke tube.

This operation of the "U" tube by pressure

difference is generally called "suction." It will be seen that the petrol will pour out into the choke entirely unatomised. One of the purposes served by diffuser air is to break up and atomise the fuel before it gets into the choke.

Fig. 169 shows a pipe, supplying air below the ordinary fuel level in the "U" tube. Air will be driven in and mix with the petrol as shown. The latest carburettors in their arrangement conform to the scheme shown in Figs. 167 to 169, but in some cases the choke tube is of the streamline type, whilst in others of the "tube" type.

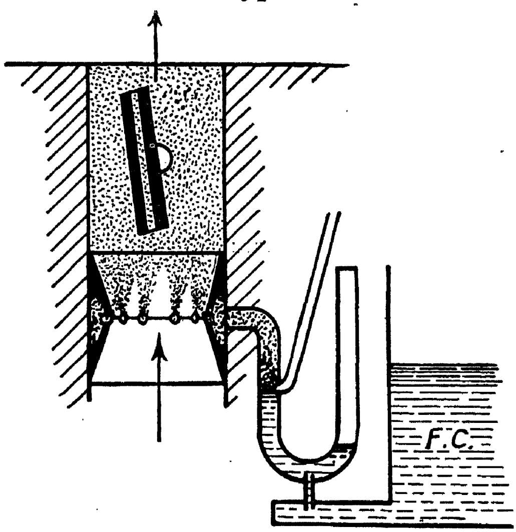


Fig. 169.

In Fig. 170 the carburettor is shown in the slow running idling condition, the diffuser is inoperative and petrol is flowing from the slow-running jet, being mixed with air from the holes in slow-running tube It is then ejected beside the throttle, and *via* the transverse passage into the centre and other side of the carburettor uptake. This type of throttle gives a perfectly distributed mixture over the whole area of the carburettor out-take, prevents loading up whilst idling and eliminates flat spots during the first portion of the throttle opening.

In Fig. 171 the throttle is slightly more open, the slow-running and transverse holes are still functioning and the diffuser beginning to act. It will be noted that the first row of depression holes is uncovered, and air is proceeding *via* these holes to mix with the petrol and form an emulsion.

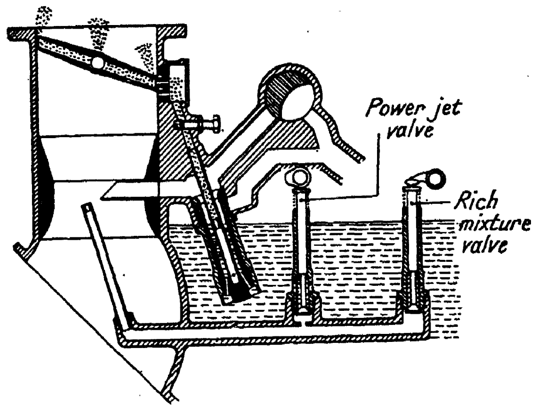


Fig. 170. Slow Running Conditions.

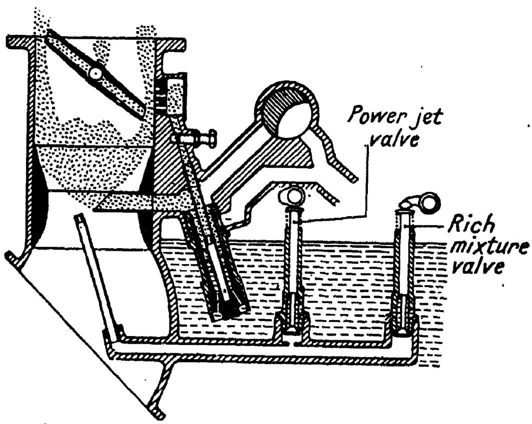


Fig. 171.—Carburettor Throttle Slightly Open.

In Fig. 172 the condition is that of full power. The slow-running and transverse passage is out of action. The diffuser is in full action, and all depression holes are uncovered and taking air to mix with the fuel. In addition, the power-jet valve has opened and added petrol to that supplied by the main jet, in order to

convert the economical cruising mixture given *via* the diffuser to the richer mixture necessary for maximum power.

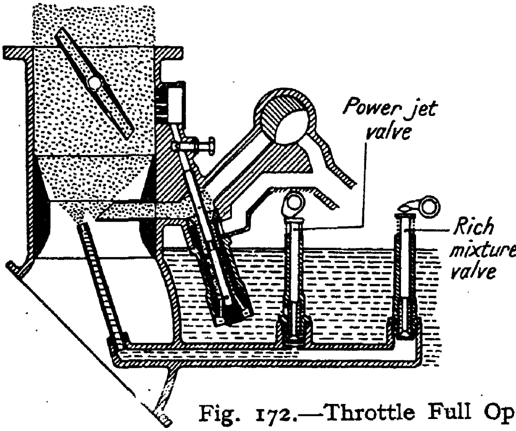


Fig. 172.—Throttle Full Open

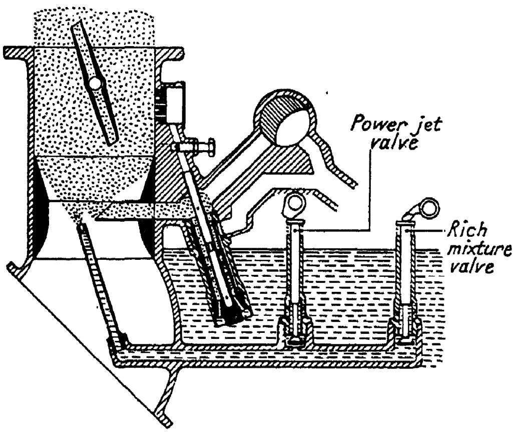


Fig. 173.—Rich mixture for take-off from the ground.

In Fig. 173 the carburettor is shown in the condition for take-off from the ground. It is assumed that the carburettor is operating with a Hobson induction pressure (boost) control and that the over-ride of this control is in action. The rich-mixture valve—working in conjunction with the boost control over-ride—is open, and is shown supplementing the normal fuel supply of the carburettor. This supplementary fuel supply gives about 10 to 15 per cent. more fuel

and enables an increase in horse-power to be obtained without detonation or overheating.

In Fig. 174 the carburettor is still shown in full power condition, but the cock for mixture control and its connecting passage are shown open. It will be seen that the admission of air through the mixture control cock into the emulsion passage will weaken the suction on the jets, in proportion to the air admitted through the cock. The rich mixture valve is shut.

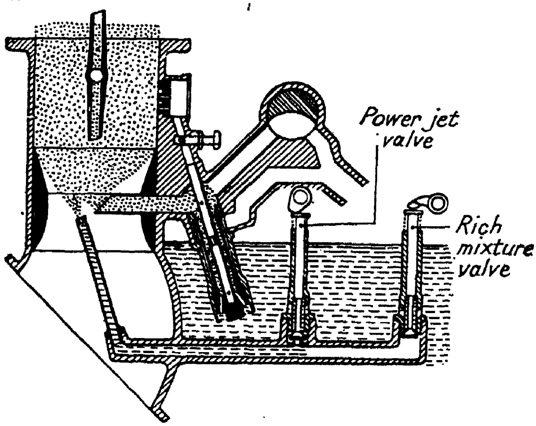


Fig. 174.—Full throttle mixture control operation.

Ice Formation in Carburettors.—It is a well-known fact that when a volatile liquid evaporates the temperature around is lowered, owing to the latent heat of evaporation effect. Applied to the fuel jet of a carburettor this evaporation lowers the temperature of the intake air and if the latter contains any moisture some of the latter will be condensed. If the outside temperature is low, as in winter, in Arctic regions or at higher altitudes—in the case of aircraft engines, the moisture in the air will tend to form ice on all internal surfaces exposed to the mixture stream.

Thus, in an unheated carburettor, ice formation is liable to occur when the relative huuidity is over 60 per cent., with intake air temperature between + 18°C. and – 10°C.

As this becomes a serious matter in aircraft engines, steps must be taken to overcome this difficulty.

Among the methods employed are the following:—

(1) Heating the intake air.
(2) Heating the metal surfaces, i.e., the choke and mixture chamber, on which ice is liable to form. Water or water-and-glycerine and oil have been proposed for jacketing the areas in question.
(3) The use of ice preventives or inhibitors. Thus if certain alcohols such as *ethanol* or *methanol* be added to the fuel, freezing can be avoided. An alternative method* is to use an ice detector and automatic servo mechanism to deliver alcohol on to the surfaces liable to be frozen until the ice is dispersed.

In the case of the Stromberg car carburettors, formation of ice on the throttle and in the idling jets during the period immediately after starting operations is prevented by fitting a thin gasket between the carburettor flange and the inlet manifold; this allows heat to flow to the carburettor body as quickly as possible after starting. A thick copper-asbestos gasket is used to separate the float chamber body from the throttle barrel unit. It is found necessary with this arrangement to use large idling passages in the throttle barrel as, when the engine is hot, most of the fuel passes through these channels in the vaporized state.

In certain aircraft carburettors the choke tubes are provided with jackets through which hot lubricating oil from the engine circulates. In some types, notably the S.U., the throttle valve is made hollow and is heated by hot engine oil.

With petrol-injection spark ignition engines, where the fuel is injected direct into the engine cylinders icing troubles do not occur.

In most British aircraft engines the carburettor main air inlet pipe is provided with alternative "hot" or "cold" air intakes. For the former purpose the air is drawn from inside the engine cowling where, on account of the heated engine surfaces its temperature is well above that of the outside air.

* "Ice Formation in Carburettors." W. C. Clothier. *Proc. Roy. Aeron. Society.* 1935.

CHAPTER X.

LOW PRESSURE FUEL INJECTION SYSTEMS.

In recent years a considerable amount of research work has been carried out upon the subject of injecting the petrol or other fuel directly into the induction manifold or engine cylinder, so as to be able to dispense with the ordinary carburettor. The method in question employs a fuel injection pump or equivalent device to supply the fuel under pressure to a small orifice injection nozzle in the inlet manifold or cylinder head.

As a result of these experiments satisfactory injection systems are now employed in commercial automobile and aircraft engines. Notable examples of the former systems include the Waukesha-Hesselman, Allis-Chalmers, Marvel and Fiat ones, whilst for aircraft engines mention may be made of the German system employed on Mercedes-Benz and Junkers petrol engines and the American one on the Continental air-cooled opposed cylinder engines.

In connection with these petrol injection methods it should be pointed out that they must not be confused with the fuel injection systems of compression-ignition engines in which considerably higher compression ratios, namely, from 14:1 to 20:1 are employed and the fuel is ignited in the combustion chambers by the heat of compression of the air.

The petrol-injection engine uses relatively low pressures, namely, from 6:1 to 7·5:1 and employs electric spark ignition.

The advantages claimed for the fuel-injection spark ignition engine are as follows:—(1) Better distribution of fuel and air (mixture) to the cylinders, since there is usually no inlet manifold as the air is drawn into each cylinder direct. (2) Higher volumetric efficiency

due to the absence of carburettor and inlet manifold; these cause a certain amount of obstruction to the mixture flow and result in the cylinders not receiving their full charges. (3) Elimination of backfires. (4) Freezing, or icing up troubles in very cold weather are avoided ; in the case of aircraft engines freezing must be prevented : this is a notable difficulty. (5) Better atomization of the fuel. (6) The use of alternative fuels of lower flashpoint than petrol is practicable. (7) Absence of the modern complicated carburettor with its various automatic mixture compensation devices, float chamber, etc.

There is little doubt that the petrol injection system gives rather better distribution and a higher volumetric efficiency and that for certain purposes—notably in connection with the satisfactory use of lower grade fuels—it is preferable to the carburettor.

On the other hand the system in question requires a somewhat complicated fuel pump with a separate plunger and pipe line to each cylinder head, and one or more injection nozzles per cylinder. Moreover, its use necessitates a separate engine drive for the fuel pump's camshaft so that an additional wearing member is thus substituted for the carburettor which has no continuously moving parts. The petrol injection system, which requires also the usual spark ignition equipment of the carburettor-type engine, is generally more costly and bulkier than the usual carburettor one.

In regard to the operation of the petrol injection system this requires equivalent devices to those of the carburettor for slow-running, acceleration, atmospheric conditions, speed and throttle range control, etc. These variations are obtained by altering the quantity of fuel delivered per cylinder, by means of a suitable control on the fuel pump.

Fuel Injection System.—The usual fuel injection system used for petrol engines is that known as the "jerk-pump" one, the principle of which is illustrated in Fig. 175. There are two separate units, namely, the fuel injection pump (shown on the left) and the injector (right). The plunger of the fuel pump is moved upwards, positively, by means of a cam driven at one-half engine speed for four-cycle engines and at engine speed

for two-cycle engines; the plunger is returned downwards by means of a compression spring. Upon the down stroke fuel is drawn into the plunger barrel, through the suction non-return valve shown, from the main fuel tank. On the succeeding up stroke of the plunger this fuel is forced out through another non-return valve into the fuel pipe line leading to the injector. The fuel is pumped into this line at a high pressure, namely, from about 1,500 to 4,000 lbs. per sq. in. This pressure is communicated through the inclined passage shown by the arrows in Fig. 175 to the lower surface of a conically ended plunger or valve, and it lifts the latter against the closing action of the compression spring shown above and opens an orifice in the lower end of the injector—termed the nozzle—thus allowing the fuel to be sprayed through the hole in the nozzle at a high pressure. The fuel which issues into the cylinder is in the form of a finely-pulverized spray of limited cone angle. If a wider angle is required the nozzle is provided with several fine holes or with a special mushroom type valve for producing the required shape of spray.

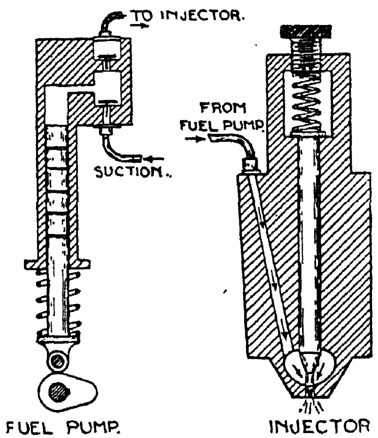


Fig. 175.

It will be evident that the moment at which the fuel is sprayed into the cylinder is determined by the shape and position of the fuel pump cam so that this type of fuel pump "times" the injection itself. There is, however, another fuel injection system in which the fuel at relatively low pressure is supplied to a mechanically-operated combined pump and injection valve which takes the place of the injector previously described; this is termed the "common rail" or "timed valve" injection system.

In practice the fuel injection pump is of a more complex type than the simple example shown in Fig. 175, since it must be provided with means of regulating and varying the quantity of fuel injected per stroke to suit the engine load requirements. For this pur-

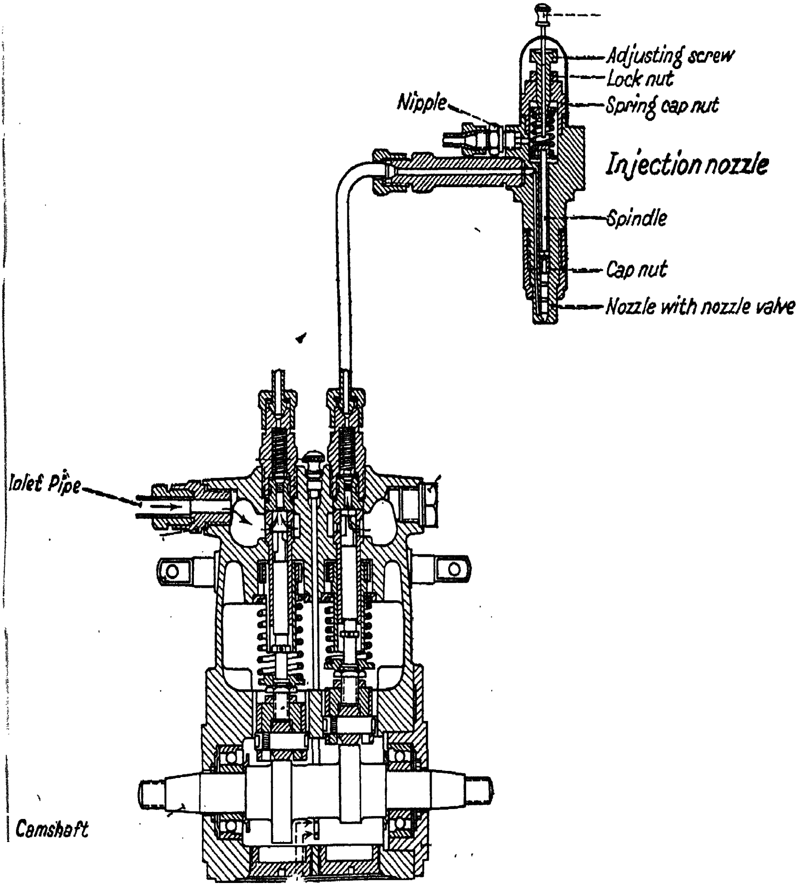


Fig. 176.—C.A.V.—Fuel Injection Pump and Injection Nozzle.

pose the upper end of the pump plunger is provided with a special shape of channel—usually of helical form, and this channel covers and uncovers fuel inlet holes or ports in the plunger barrel. By rotating the plunger about its axis the relative positions of the

helical channel and the inlet holes can be varied and in this manner the quantity of fuel pumped can be altered, but without affecting the timing of the injection.*

Fig. 176 illustrates a typical fuel pump and injector of the C.A.V. pattern with dual plungers for supplying a two-cylinder engine.

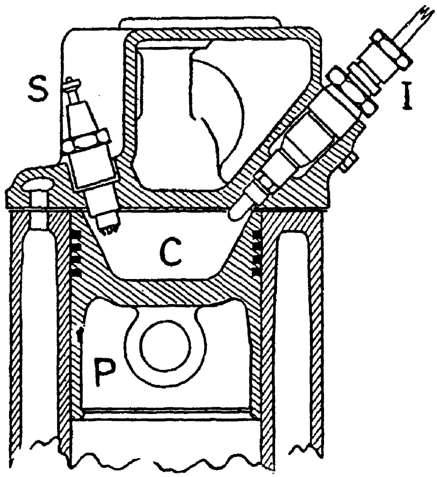


Fig. 177.—Cylinder Head of the Hesselman Engine.

Typical Fuel Injection Spark Ignition Engine.—A sectional view of the Hesselman engine cylinder head is shown in Fig. 177. The piston P is of the cavity type and on its top dead centre position on the compression stroke acts as the combustion chamber C. The fuel injection nozzle I is arranged on one side of the combustion head and the sparking plug S on the opposite side. When the air which is drawn into the cylinder during the downward suction stroke of the piston is compressed on the following upward stroke it has a certain amount of turbulent motion which assists the air in mixing with the injected fuel particles. The fuel-laden air as it sweeps past the sparking plug is ignited by the ignition spark and this ignited fuel in turn causes the rest of the fuel to burn.

* A full account of injection pumps and injectors is given in "High Speed Diesel Engines." A. W. Judge. (Chapman and Hall, Ltd.).

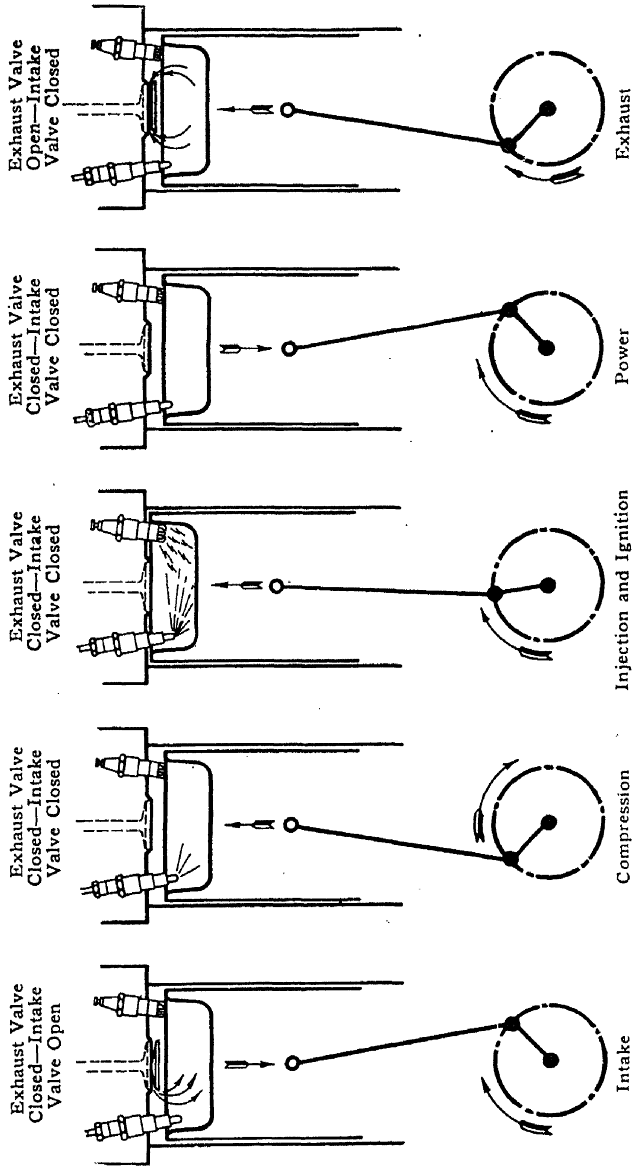


Fig. 178.—Complete Cycle of Operations of the Waukesha-Hesselman Engine.

Fig. 178 shows, diagrammatically, the complete cycle of operations of the four-cycle Waukesha Hesselman engine which operates in a similar manner to the

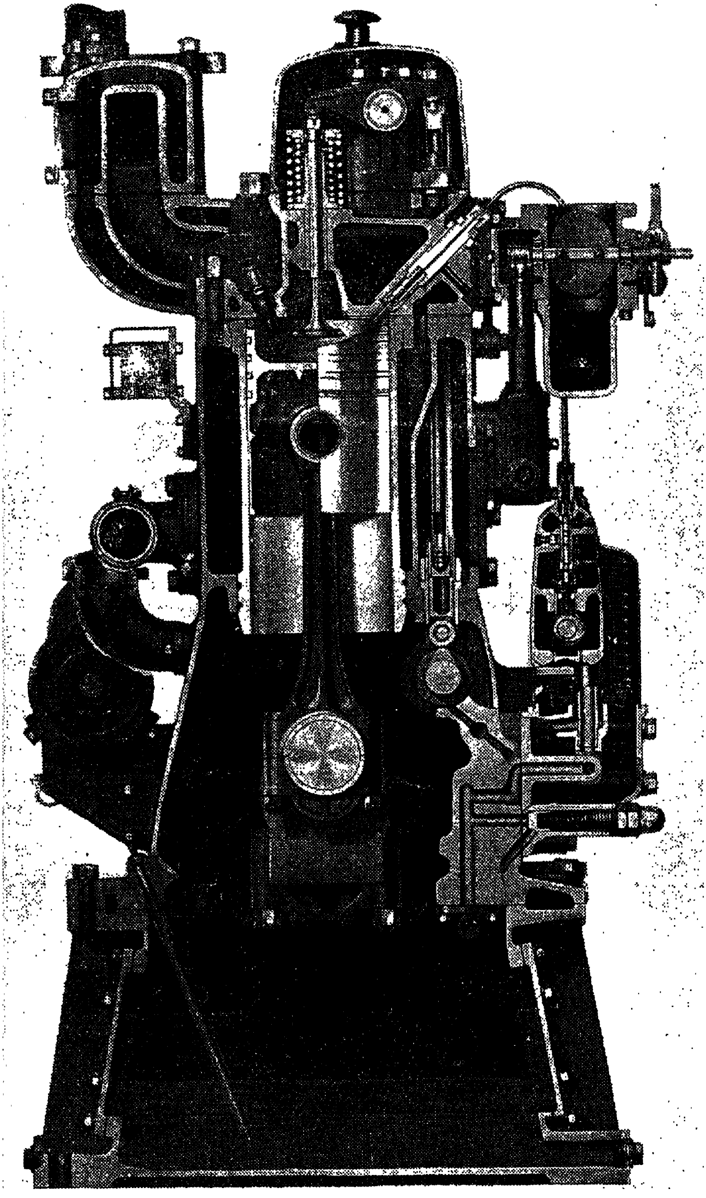


Fig. 179.—Cross-sectional View of the Waukesha Hesselman Engine.

engine previously described. The exhaust and air intake valves are of the overhead types actuated by push rods and rocker arms from a camshaft below. As these two valves are arranged one behind the other they are not shown separately in Fig. 178.

A cross-sectional view of the Waukesha Hesselman engine is given in Fig. 179. This illustration shows the fuel injection pump on the right centre with the fuel feed pipe leading to the injection nozzle on the

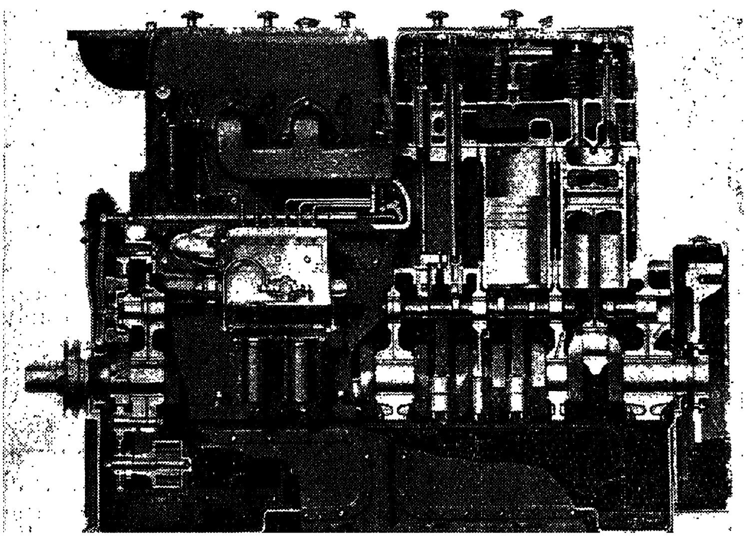


Fig. 180. The Six Cylinder Waukesha Hesselman Engine.

left side of the combustion head. The overhead valve operating mechanism is also shown.

The engine in question is made in several sizes, in the six-cylinder type, from the smallest of $3\frac{3}{4}$ in. bore and $4\frac{1}{4}$ in. stroke developing 33·8 B.H.P. (rated) to the largest of $6\frac{1}{2}$ in. bore and 8 in. stroke giving 67·6 B.H.P. (rated); the actual horse power developed is, however, much higher than the rated power. A typical six-cylinder automobile engine of $4\frac{1}{2}$ in. bore and $5\frac{1}{2}$ in. stroke develops 125 B.H.P. at 2,100 R.P.M.,

which corresponds with a brake M.E.P. of 88 lbs. per sq. in.; the compression ratio is 5·8:1.

A special feature of this engine is that it can be operated either as a fuel injection spark ignition engine or as a simple petrol engine. In the latter instance the elbow air intake manifold is removed and a petrol carburettor substituted; the fuel injection equipment can be removed and plugs fitted in place of the injection nozzle. The fuel consumption is 0·5 lb. of Diesel oil per B.H.P. per hour. The total engine weight is 1,340 lbs., i.e., 10·7 lb. per H.P.

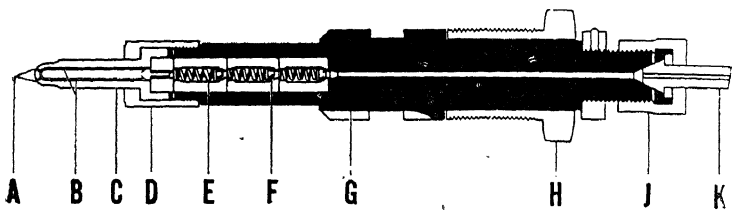


Fig. 181.—The Hesselman Fuel Injection Nozzle.

A—Twin openings in nozzle tip. B—Twin grooves in nozzle insert feed fuel to tip openings. C—Stainless steel nozzle tip. Sleeve type copper gasket fits over this. D—Nozzle assembly nut. E—Triple spring check valve. F—Half ball checks. G—Keyway slot locates nozzle in combustion chamber. H—Nozzle hold-down nut screws into cylinder head. J—Fuel line compression nut. K—Steel fuel line.

Another side view, in part section, of the same engine is given in Fig. 180. The fuel injection pump, fuel feed lines and three of the injection nozzles (for the three cylinders on the left) are shown, whilst a sectional view through the cylinder on the extreme right illustrates the valve and piston arrangement.

The type of fuel injection nozzle used on these engines is shown in Fig. 181.

This is a simple open type injector having three check valves E arranged in series so as to prevent fuel from dribbling out of the nozzle tip and also to isolate the combustion pressure effects from the fuel supply to the nozzle. The nozzle tip is covered by a soft copper bushing to assist in conducting the heat away from the tip to the wall of the cylinder head. At the end of the nozzle tip—which is made of nitralloy steel

of great hardness—are two spray holes, which for the smallest size of engine are of 0·012 in. diameter and for the largest one 0·029 in. diameter.

The engine speed is controlled by means of a special governor mechanism of the vacuum-operated type, using the partial vacuum existing in the air intake manifold. The manner in which this control operates is shown, schematically in Fig. 182. It will be observed that this vacuum device actuates the fuel injection pump mechanism in such a way that when the vacuum

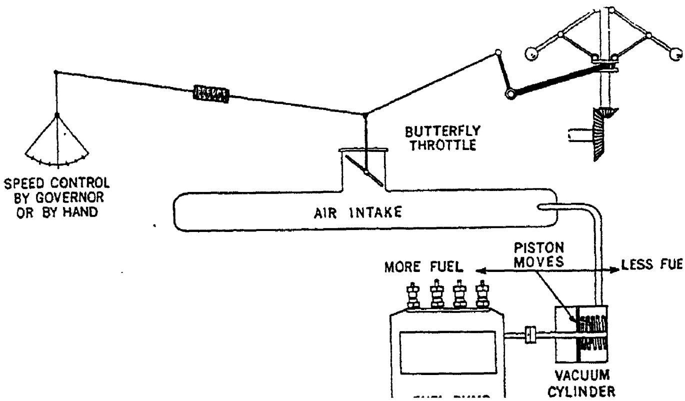
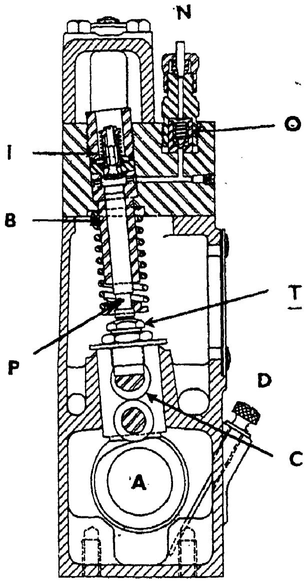


Fig. 182.—Governor Arrangement for Fuel Injection Spark Ignition Engine.

increases—as under part load conditions—the fuel pump supplies less fuel and if the vacuum decreases as when the air intake throttle is opened for full load conditions by the centrifugal governor control more fuel is supplied. In this way the ratio of air-to-fuel is kept constant over the whole load range. A hand (or pedal accelerator) control is provided for over-riding the governor control between the minimum (idling) and maximum output speeds.

Another engine of the same class is the Allis-Chalmers, the combustion head of which is similar to that shown in Fig. 177. The compression ratio used is 6·4 : 1, corresponding to a compression pressure of about 160 lbs. per sq. in. Fuel injection into the air charge begins at about 50° before top dead centre on

the compression stroke and this continues until about 10° before top dead centre. The ignition spark occurs at 12° before top dead centre. Owing to the time required for the fuel to vaporize, not all of it will ignite at once, so that combustion takes place gradually and the maximum pressure is reached at about 15° to 18° past top dead centre, with the engine operating under



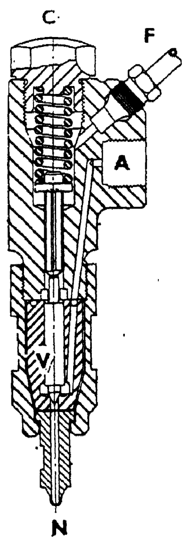


Fig. 183. Fig. 184.

Fig. 183.—The Deco Fuel Injection Pump.

A—Camshaft. B—Pump barrel. C—Fuel quantity control shaft. D—Lubricating oil level dipstick. I—Fuel inlet valve. N—Fuel pipe to injector. O—Fuel outlet valve. P—Fuel pump plunger. T—Adjustable plunger tappet.

Fig. 184.—The Deco Fuel Injector.

A—Fuel pipe connection from pump. C—Valve spring cover nut. F—Fuel leak-off pipe. N—Nozzle end situated in combustion chamber.

full load conditions. At part load injection begins somewhat later, but the timing of the spark is fixed and the rate of combustion is controlled by the timing of the fuel injection. At full load the total amount of air admitted to the engine is used for combustion

the ratio of air to fuel being about 15:1 to 16:1. At part load the amount of air admitted is reduced by a governor-controlled butterfly throttle between the air cleaner and air inlet manifold. The quantity of fuel injected is controlled by a vacuum governor as in the Waukesha Hesselman engine; under these conditions the air-fuel ratio is maintained constant.

The Deco type of fuel injection pump shown in Fig. 183 is used with the system described. It has three main structural parts, namely, the housing, body

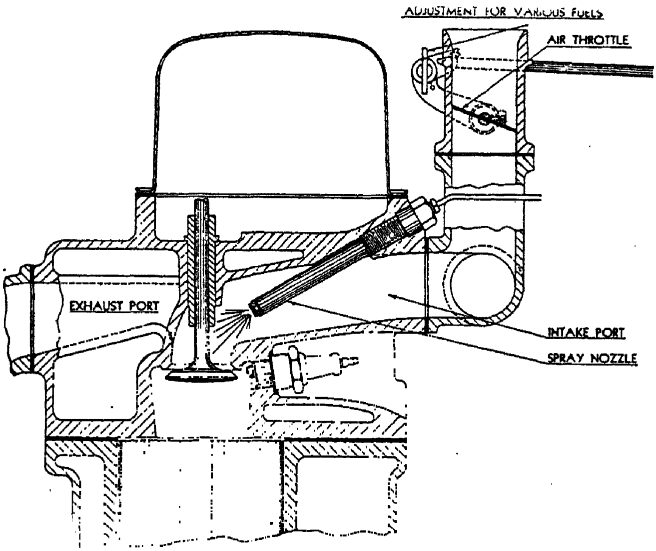


Fig. 185.—The Marvel Low Pressure Fuel Injection System.

and suction valve cover. Each cylinder of the engine has its own fuel pump plunger assembly and fuel feed line. In order to control the amount of fuel injected the plungers are made of variable stroke by interposing a specially-contoured control rod between the pump camshaft operated tappet rollers and the tappet screws (Fig. 183). The section of the control rod—which extends the full length of the pump housing and is parallel to the cam shaft—within the hollow tappet bodies is machined flat and by its rotation the stroke and therefore the amount of fuel injected can be controlled. The fuel injection pressure is

1,350 lbs. per sq.in. As soon as this plunger reaches the end of its upward stroke the pressure falls below this value and injection ceases. The fuel injection nozzle is shown in Fig. 184, and belongs to the spring-loaded hydraulically opened valve class. By altering the compression of the spring the opening pressure of the valve can be varied. The fuel from the pump is admitted through the union hole shown on the right below the fuel leak off union—which leads any fuel leaking past the valve stem away from the injector. From the lower union the fuel passes down the inclined bores to the foot of the valve. The control end of the latter forms an oil-tight seating on the nozzle ejection hole. The extension tip of the nozzle is of special design to give the correct shape of fuel spray and penetration of the latter into the air charge.

Other Injection Systems.—In both of the engine types previously described the fuel is sprayed into the cup-shaped piston head during the compression stroke, but there are now several other fuel injection systems for spark ignition engines which have been patented; some of these are now in commercial use. In the Marvel low pressure fuel injection system (Fig. 185) the fuel is sprayed on the top surface of the overhead air inlet valve during the air induction stroke, whence it receives sufficient heat to vaporize it. In this design the combustion chamber is of practically cylindrical form and the compressed air and fuel charge are given a turbulent movement in the combustion chamber towards the end of the compression stroke to facilitate the fairly rapid burning of the fuel when and after the ignition spark occurs at the plug shown on the right below the inlet valve. This fuel injection system is applicable to engines using various grades of fuel, there being an adjustment on the air throttle for the different fuels to give the proper air-fuel ratio for combustion. There is a positive connection between the air throttle and the fuel measuring needle of the fuel pump to give the correct air-fuel ratio over the range of engine loads.

Another low pressure fuel injection engine is the

Fiat one shown in Fig. 186.* This engine employs an auxiliary combustion chamber of cylindrical form communicating with the main cylinder by means of a wide-type venturi or throat. The axis of the combustion chamber is inclined to the cylinder axis and the fuel injector is arranged to spray the fuel in conical fashion axially downwards. The sparking plug is shown on the left side just below the injector. At the end of the suction stroke the combustion chamber remains filled with burnt gases and at the same pressure as the air in the cylinder. During the following compression stroke the volume of these gases diminishes continually until near the end of this stroke it is about one-seventh of the total combustion chamber with compressed air between it and the piston top. Before the piston reaches its top dead centre the fuel is injected and the particles of atomized fuel meeting the ascending column of air give rise to a uniform explosive mixture without the necessity of any turbulence. The spark then occurs at approximately the upper limit of the air-fuel zone and the fuel is thus ignited. Since a full charge of air is admitted at all loads the compression pressure remains constant and the upper end of the combustible mixture zone is always in the same position and the sparking plug electrodes are always surrounded by this mixture.

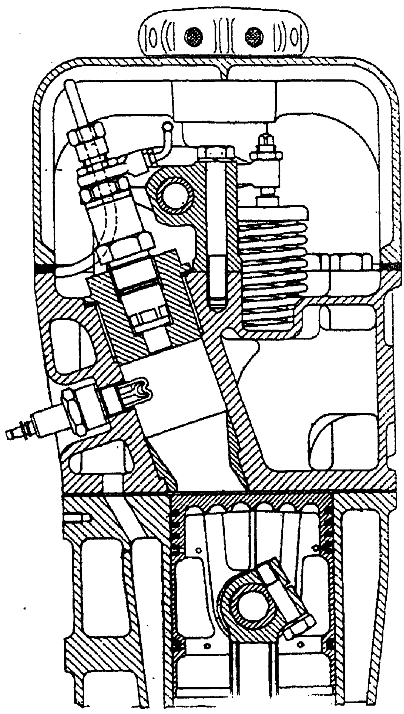


Fig. 186.—The Fiat Fuel Injection System.

* The Automobile Engineer.

The engine employs a compression ratio of 7·2 : 1 and it will operate satisfactorily with various liquid fuels including gas oil, Diesel fuel, petrol, alcohol, etc.

Tests made with this type of engine using gas oil gave a practically constant B.M.E.P. of 89 lbs. per sq. in. from 800 to 1,400 R.P.M. and a fuel consumption rising from 0·47 lb. per B.H.P. hour at 800 R.P.M. to 0·52 lb. per B.H.P. hour at 1,600 R.P.M., corresponding to full load. When run on alcohol the fuel consumption was about 0·78 lbs. per B.H.P. hour at

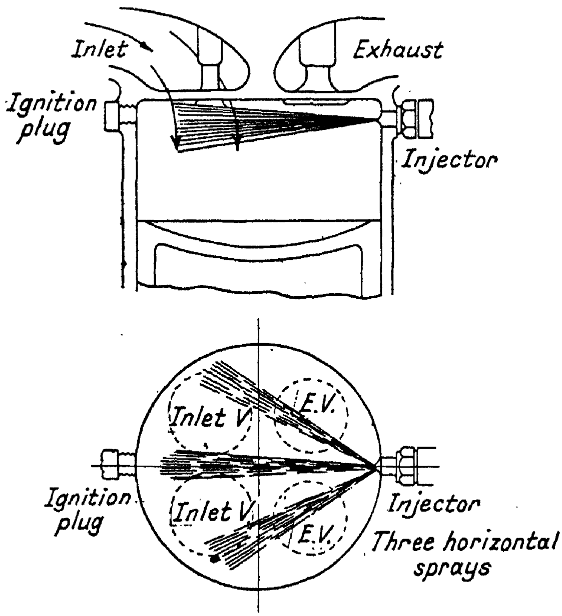


Fig. 187.—Fuel Injection System used on Aircraft Engine.

800 R.P.M. and 0·82 lbs. per B.H.P. hour at 1,600 R.P.M. The B.M.E.P. was practically constant at about 92 lbs per sq. in. Under part load conditions the fuel consumptions were invariably higher at any given speed than under full load conditions; the lowest consumptions were given for three-quarters full load conditions.

Fig. 187 illustrates the method of fuel injection employed in a typical aircraft engine. It uses a three-

spray injection nozzle which operates during the induction stroke. The nozzle in question is arranged on the opposite side of the cylinder to the sparking plug.

As a final example of a fuel injection spark ignition the Daimler Benz system, shown in Fig. 188 will be described. In this engine two sets of fuel injectors, one of which is shown at A, are employed in order to obtain a much better fuel distribution than is possible with a single injector. Two sparking plugs, one of which is shown at B, are used for ignition purposes. The engine in question has two inlet valves C and two exhaust valves D.

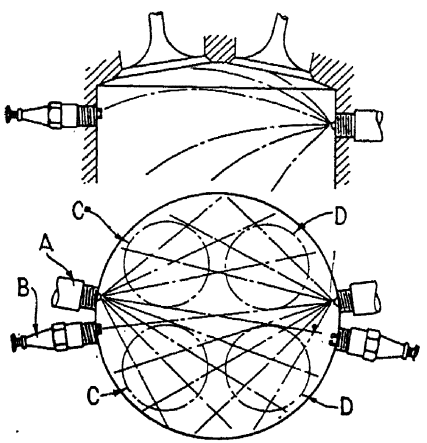


Fig. 188.—Daimler Benz Fuel Injection System.

This arrangement of injectors, valves and sparking plugs ensures that the zones in the immediate vicinity of the injectors are suitably enriched with fuel, so that the sparks occur under good combustion conditions. The fuel jets are made to impinge on the sparking plugs, valve heads and piston head, thus giving a cooling effect owing to fuel vaporization. The nozzles are located as low in the cylinder walls as possible in order that they may be covered and thus protected by the piston against the high pressures and temperatures during combustion; the nozzles are generally inclined downwards.

It may here be mentioned that in the case of *supercharged engines* using an engine-driven or exhaust-turbine driven centrifugal type of air compressor, in which the air is drawn through a central orifice and discharged from the outer tips of the impeller vanes, the fuel may be injected axially in the direction of the air intake to the compressor. In this manner good

admixture of the fuel and air is ensured and there is no necessity for injectors in the individual cylinders. A single injector of the multiple hole or conical sheet spray type is used for the purpose and the vaporization of the fuel assists in cooling the compressed air, thus improving the charge efficiency. When separate cylinder-type injectors are employed this beneficial cooling effect is not obtained.

CHAPTER XI

FLOATLESS AND MODEL ENGINE CARBURETTORS

The elementary form of carburettor, as has been shown, is merely a fuel jet in an air-supply tube; the level of the fuel in the jet is maintained constant by means of the float-chamber.

Many attempts have been made to dispense with the float-chamber, and thus to feed the petrol direct to the induction pipe, along with the appropriate quantity of air. Apart from the simplification thus effected, such an arrangement will have the additional advantage of permitting the engine to work in practically any position, or inclination.

The Diesel principle of feeding the fuel direct, through a suitable metering device, into a cylinder of compressed air, raised in temperature, by the compression to above the ignition point, is a typical example of floatless fuel feed.

This same principle was applied about 1910 by the writer to a two-stroke engine, in order to overcome the drawback of fuel wastage through the exhaust, when both the crankcase inlet and exhaust outlet on the cylinder were uncovered at the same time by the piston. The crankcase in this example was used to compress the air supply only. After this had been forced into the cylinder, and the exhaust port was closed on the upward movement of the piston fuel was pumped through an atomizing valve into the cylinder, to form the mixture for combustion at the top of the compression stroke. In this case, mixture strength could be varied merely by regulating the quantity of fuel injected.

Mixing Valves.—The other method of dispensing with the float-feed system is to use what is called a

"*Mixing Valve*". In this case the fuel is drawn in through the inlet pipe, along with its air supply by the ordinary suction of the engine.

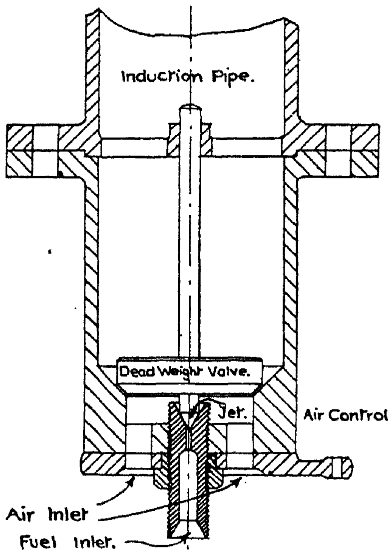


Fig. 189.—A Simple Mixing Valve.

It is usually arranged for the air to be admitted through a poppet-type valve, in the seating of which is a small orifice for the petrol to flow. When this valve is lifted in virtue of the engine suction, the seating being uncovered, the petrol is drawn into the engine.

Fig. 189 shows an elementary form of mixing valve* that was originally fitted to a gas engine. This consists essentially of a conical air inlet valve, deadweight loaded, the stem of which terminates in a needle valve controlling a fuel jet. The passage of air through the main valve will cause it to rise, opening the fuel valve at the same time, and the fuel, fed by gravity to the jet, will mix with the entering air. Mixture control is effected by an air shutter at the intake. As simultaneous closure of both air and fuel valves is scarcely practicable, the height of the jet is adjustable, so as to set the fuel valve to shut before the air valve is quite on its seating.

The principal disadvantages of this simple mixing valve as applied to petrol engines, are as follows:—(1) It is not automatic. (2) The fuel is not atomized properly, for it does not enter at the maximum air velocity position; and (3) excessive wear on the needle due to pulsating action.

*"Mixing Valves for Internal Combustion Engines." E. Westbury. *English Mechanics*, Nov., 1931.

Fig. 190 shows an improved design of mixing valve in which there is a central choke to allow the jet to operate in the high velocity air stream; this discharges at or above the air valve seating.

An improvement over the preceding design is illustrated in Fig. 191. In this case the air valve is now spring loaded; and the fuel jet, instead of having a needle valve to control it, is situated actually *in* the seating of the air valve itself, and therefore closes simultaneously with it.

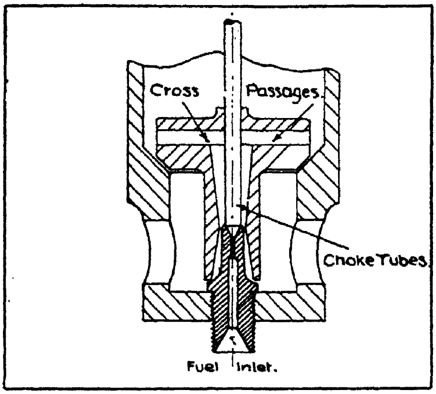


Fig. 190.—Improved Mixing Valve with central choke for atomising the petrol.

It will be seen that in this form of mixing valve the fuel orifice is situated in its correct position; this ensures good atomisation at all speeds. A plain capillary orifice may be employed to meter the fuel, but it is generally more convenient to fit a screwed needle valve to control its output. The lift of the valve may be limited by the adjusting screw above it, which will thus act as a throttle control. On many engines, however, the best speed is attained by limiting the valve lift so that the beat of the valve naturally synchronises with the suction period. In this respect it is worthy of note that on a high-speed engine the

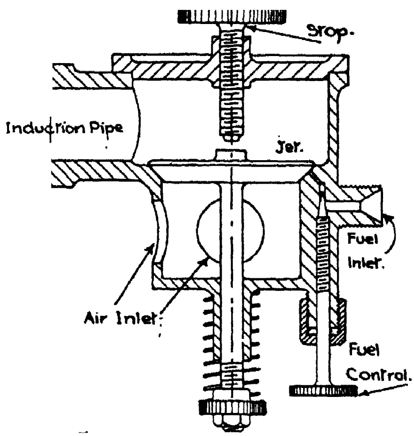


Fig. 191.—Mixing Valve with jet in seating of air valve.

valve must move very rapidly. The valve, therefore, must be extremely light, and loaded by means of a light spring, variable in tension, so as to be adjustable to suit the engine.

Mixing valves similar in principle to that shown in Fig. 191 were used on the Evinrude and other outboard motors, and there is at least one case on record of the successful employment of a mixing valve on a motor-cycle engine.

Vac-U-Matic Floatless Carburettor.—The carburettor shown in Fig. 192 is known as the Vac-U-Matic", and has been used on low-powered aircraft engines in America. It has no float chamber or float, and is claimed to give satisfactory mixture regulation over the whole speed range.

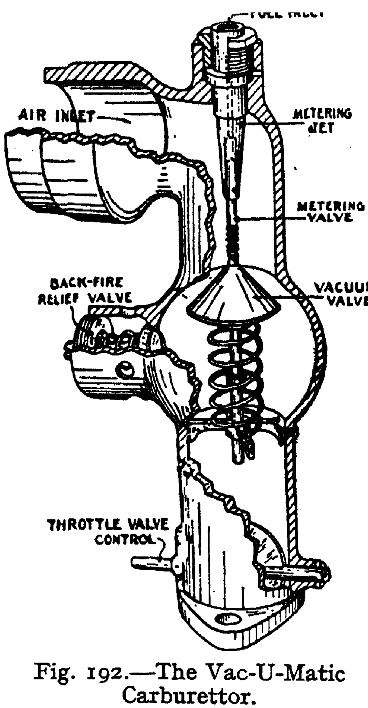


Fig. 192.—The Vac-U-Matic Carburettor.

There are no adjustable items such as "idling" mixture screws, and only one moving part in the one-piece casting unit.

In operation, the suction developed by the engine pulls the vacuum valve away from its seat against the pressure of the spring, which permits the passage of air into the manifold and into the cylinder. The vacuum valve is resiliently connected with a simple metering jet by means of a metering valve. This plunger moves simultaneously with the vacuum valve. Thus the engine by its suction regulates the amount of mixture drawn in by the throttle, and so maintains the proper ratio of fuel and air at all speeds. Tests have proved that the carburettor does not choke up or give

too rich or too weak a mixture. The vacuum cone reseats itself when back-pressure develops. Should a back-fire occur the relief valve shown opens outwards and the dangers of back-fire are thus practically eliminated.

The absence of the usual float chamber renders the carburettor suitable for engines, such as aircraft ones, which have to operate at various inclinations, or even upside down.

The Degory "No-Jet" Carburettor.—The Degory "No-jet" carburettor is an interesting example of a jet-less carburettor. From Fig. 193 it will be seen that, the choke tube being in place, the chambers E and D form but one chamber, the only outlet being the small holes of the choke tube. When the engine is started, the throttle is slightly open and the suction causes a high-velocity air current between G and F in which an air current starting from J passes over

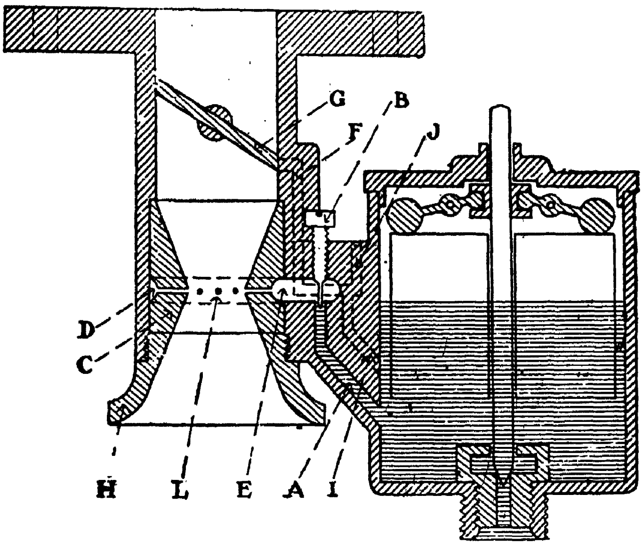


Fig. 193.—The Degory "No-Jet" Carburettor.

the channel I, forming the mixture there, which then follows the channel F and into the engine; this gives the slow-running condition. As the throttle is opened, the suction ceases in the channel F, but increases in the chambers D and E, and as these have only one

outlet viz., the small holes, F, in the choke tube, H, the fuel passes through these holes in a direction at right angles to the main air current. A regulating screw, B, is provided for the petrol supply, and also one for the zero throttle setting. It will be seen that the submerged jet or well principle of the petrol supply will tend to render the mixture constant with speed increase.

Amal Jet-less Carburattor.—This carburettor is designed for small engines, and avoids the use of the small jets that otherwise might be necessary.

It is automatic in action, and the throttle is controlled by a single lever and flexible cable; an adjustable needle is attached to the throttle and dips into a petrol well.

An alternative design provides for the air control for cold starting, either as a knife-type strangler in the air intake or an air slide in the throttle chamber.

The petrol feed is on the top of the float chamber, through the lid. A "tickler" is provided for raising the petrol level for starting. The feed to the jet chamber is by annular duct, which is plugged at the outer end by a screw, which may be taken out for cleaning purposes. *The jet* may be removed by unscrewing the hexagon plug underneath the mixing chamber.

The throttle is of the piston type, having two slots in its side, one being for the attachment of the control wire, and the other to slide over the top screw of the side of the mixing chamber body, to keep the throttle from rotating. The bottom of the throttle is specially shaped with a cut away of suitable dimensions to correct the mixture at small throttle openings. Underneath the throttle, in the base of the mixing chamber, there is a small hole to allow petrol to drain away from the jet plate.

The needle for controlling the mixture is suspended from the throttle, and has several grooves at the top, and one of these is embraced by a split disc to locate the position; the control wire passes through the D-shaped hole in the disc, and the throttle spring holds the disc firmly in the throttle. The needle so

held protrudes in a set relation to the throttle, and as the throttle is opened, so the needle is retracted from the jet, and the restriction to the flow of fuel is reduced—and vice versa.

In the cap of the mixing chamber top there is a *cable adjusting screw* and lock nut, which can be adjusted to take up any slack movement in the control lever, or alternatively, can be screwed up to set the throttle open for slow running when the hand lever is in a closed position.

These carburettors are not intended for general use, but are supplied to engine makers, correctly tuned for a given type of engine.

Mixing Valve for Gaseous Fuel.—The mixing valve principle can readily be applied to gaseous fuels; in this case, owing to the greater volume of the gas—

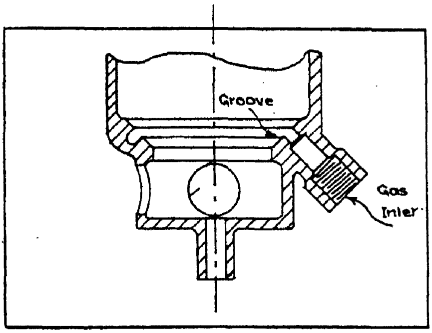


Fig. 194.—Mixing Valve for Gaseous Fuel.

and incidentally to the richer mixtures used—it becomes necessary to employ larger sizes of fuel gas orifice than for liquid fuels.

Fig. 194 illustrates one method of arranging for the supply of gas, viz., by means of a groove cut around the face of the air-valve seating; this groove is in communication with a drilled passage connected to the gas supply pipe.

Some Practical Results.—Some interesting tests using a mixing valve of special design, have been made upon a 30 c.c. two-stroke model-type high efficiency petrol engine. One object of these tests was to

examine whether the throttling action of the spring-loaded valve would affect the volumetric efficiency. It was found that, although the flat-out speed was very slightly less than was obtained with a carburettor of the straight-through type, there was no perceptible diminution in the maximum power, while, when running at reduced speed under load, there was no tendency to blowback, running was thus more even and consistent. Incidentally, when this type of mixing valve is used on a three-port two-stroke, it very much simplifies the inlet-port timing, for the above reason. Another interesting point is that, although as previously stated mixing valves are not automatically compensated, the error appears to be directly opposite to that of the simple spray carburettor; i.e., the mixture strength increases as the speed is reduced.

Carburettors for Model Engines.—The small high-speed two- and four-stroke petrol engines used on model power boats, aircraft, etc., are fitted with miniature carburettors, in most of which some form of hand or automatic regulation of the mixture strength is provided.

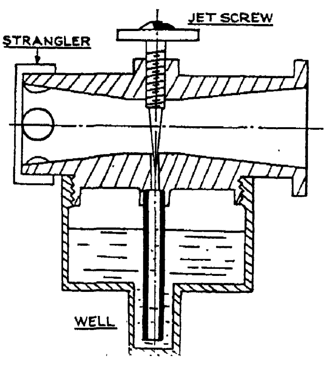


Fig. 195.—The Suction-type Carburettor.

The engines in question for model aircraft include those of 2·4, 6, 10, 15, 18 and 30 c.c.'s capacity; larger sizes are generally used on model power b

The types of carburettor employed are (1) the suction, (2) mixing valve, (3) plain float type, (4) submerged jet, and (5) mechanically compensated ones, shown in Figs. 195 to 202.*

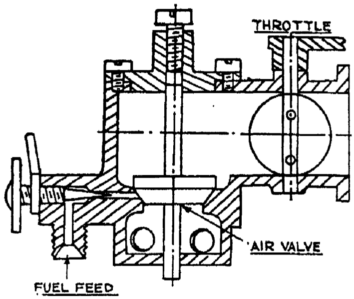
(1) _The Suction Type of Carburettor_, Fig. 195, is much used on the smaller speedboat engines and for model aircraft. Its principal advantages are that it cannot be flooded or air-locked, and that the fuel tank

"*Model Carburettors and Fuel Feeds," W. Cooper, _English Mechanics_. Sept. 25th, 1936.

can easily be exchanged for one of another capacity, to obtain a run of longer or shorter duration as desired.

Its characteristics are such that after it is once set for a given load and speed, any drop in speed or increase of load, results in weakening of the mixture. While the fuel level in the tank also gets lower towards the end of a run and weakens the mixture, although, unless the tank is very deep, this is not likely to affect power seriously. Preferably, the tank should be shallow rather than deep, with the jet tube situated in a well, which holds sufficient petrol to prevent the engine being starved, should the fuel surge about when the boat or plane is in motion.

On a steady load this is a successful type of carburettor, and its simplicity is a feature to recommend it. Heavy strangling is required to start the engine from cold.



Fig, 196.—The Mixing Valve.

(2) *The Mixing Valve.*—This has just the reverse characteristic to the suction carburettor, i.e., instead of the mixture weakening it becomes richer with a drop in speed. With an ordinary throttle in the induction pipe good control can be obtained over a wide range. There is a tendency, if anything, for the mixing valve to be over-corrected. Engines of low, or medium speed are the most suitable types for a mixing valve, as at high speed the air valve introduces a throttling effect.

Two-stroke engines usually run well with mixing valves, and they eliminate the accuracy or otherwise, of the inlet port timing, for as soon as there is an absence or a reversal of pressure in the induction pipe, the valve closes and effectively prevents blow-back.

The mixing valve can be fed either from a gravity tank or by suction, the valve being ground down to the seating seals the fuel orifice in the closed position.

(3) *Plain Float Carburettor,* Fig. 197.—The feature of all float feed carburettors is the constant head of the fuel, which keeps the mixture strength unchanged throughout a run. This carburettor is more suited to high speed conditions than either the suction type or the mixing valve types. The fuel is all ready to enter the engine when suction takes place, and has not to be lifted, with the consequent slight delay, as in the case of the suction carburettor. Nor is there any big obstruction in the pipe to cause throttling, like in the mixing valve.

Consisting of just a plain jet in a choke tube, this type can, theoretically, produce most power from the

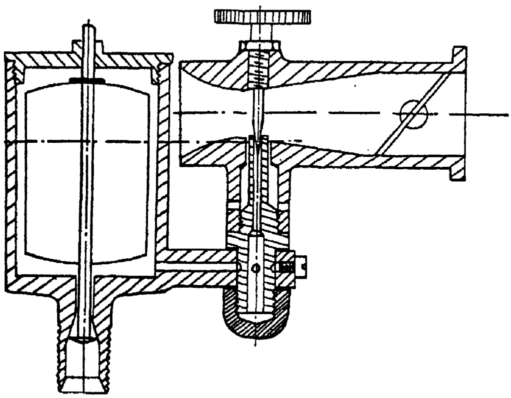


Fig. 197.—The Plain Float Feed Type Carburettor.

engine, but it almost entirely lacks compensation means. For purely racing work, this carburettor has advantages when its characteristics blend in with the other features of the engine.

Rather drastic strangling is required for starting. Judicious use of the strangler and throttle can keep the engine running, as for instance, with the model speed boat held stationary in the water, then opening up at the last moment will in all probability get the boat away. But there is a tendency to stall should a heavy load be encountered.

Simplicity is a great point of this carburettor, but it is not, however, a type to be seriously recommended to the beginner.

(4) *Submerged Jet Carburettor*, Fig. 198, illustrates a submerged jet type of carburettor. In this carburettor the fuel level is above the jet, which, in conjunction with an adjustable air leak to the jet well, provides the compensation. And the air that is admitted assists in the breaking up and atomization of the fuel.

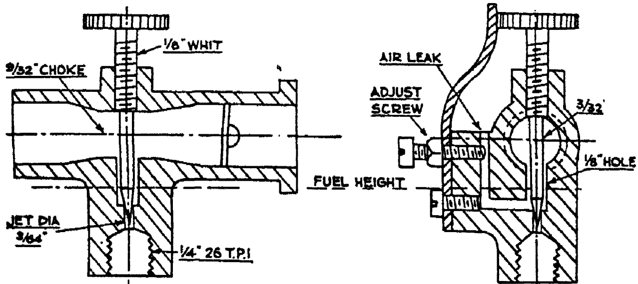


Fig. 198.—Submerged Jet Pattern Carburettor.

The principle is that with the air leak open the jet supplies practically a uniform amount of fuel over the full range of speed, and so, if set correct for low speed the mixture becomes gradually weaker as the r.p.m. increases. Conversely, with the air leak shut off, the mixture correct at low speeds becomes richer at high.

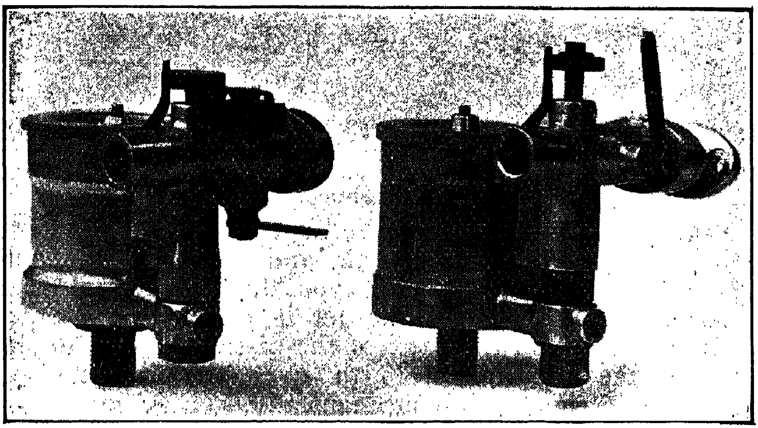


Fig. 199.—(Left) Carburettor for 15 c.c. Model Four-Stroke Engine. (Right) Model for 22 c.c. Two-Stroke Engine. (Cooper.)

The jet opening and air leak are adjusted together so as to strike the happy medium.

At low speed the fuel level over-runs the jet, and upon opening up the fuel in the well is quickly sucked into the engine, in a greater quantity than could be normally supplied by the jet, and this, of course, gives rapid acceleration. Should a heavier load be encountered by the engine when it is running well out, there is a tendency again for the fuel level in the jet well to rise and enrich the mixture.

Setting of the air leak and jet is done with the air leak shut right off, and the engine running fairly fast. The jet is adjusted so that at first the engine fires evenly. When opening up the mixture becomes richer and the air leak is opened to correct this. For normal purposes no slow running jet is required as the engine will throttle down to quite a low speed, though not quite to a "tick-over".

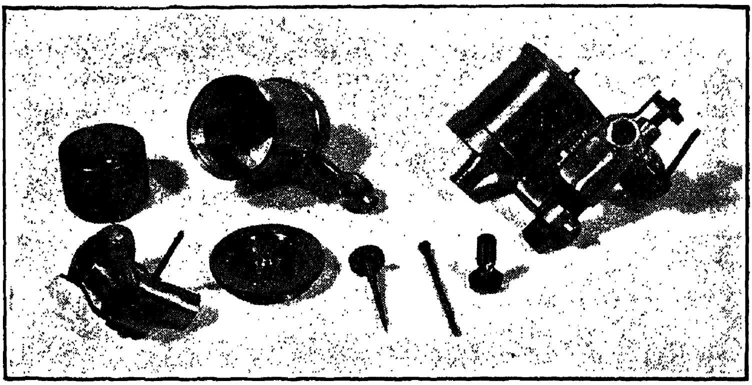


Fig. 200.—Showing Right-hand Model Carburettor of Fig. 199 dismantled.

(5) *Mechanically Compensated Type.*—The principle of this type is that the air and fuel are shut off simultaneously by a piston-type throttle acting as a variable choke bore. The jet is of the plain type. The cut-away on the back of the piston throttle determines the mixture strength over the range, and provides compensation mechanically. (Fig. 201.)

Suppose the throttle were a flat shutter situated in front of the jet: this would give a weakening mixture as the throttle was shut. With the throttle behind the jet, the reverse would be true, and the mixture would

become richer. By arranging the piston throttle to be directly above the jet any desired effect can be obtained by varying the proportion of the front and rear edges of the throttle. In practice it is found that the throttle has to be backed off about 30 to 45 degrees

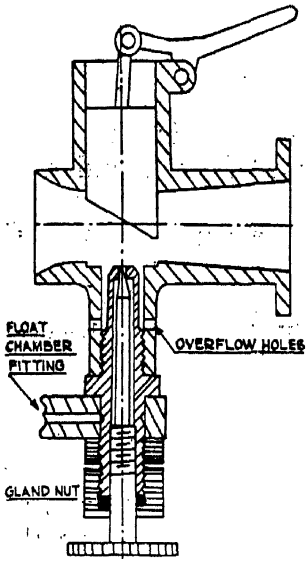


Fig. 201. Mechanically Compensated Carburettor.

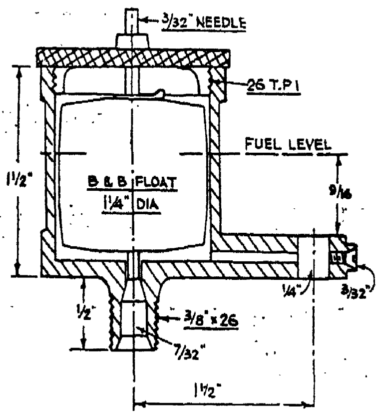


Fig. 202. Typical Design of Model Carburettor Float Chamber for 15 to 25 c.c. engine.

to obtain good mixture strength over the full range. This should be done by setting the mixture correct for full throttle and leaving it there while concentrating on the low and middle ranges of speed. For slow running a small horizontal groove in the bottom of the throttle sometimes helps.

This type of carburettor provides the best acceleration on a gradually opening throttle but resists any attempt to "force" it. It is recommended for model aircraft and stationary engines, but not usually for speed-boats.

CHAPTER XII

AIR CLEANERS AND SILENCERS

The ordinary motor car engine works in an atmosphere containing a certain amount of dust, and it is this dusty air which would normally be drawn into the carburettor. Further, on dry days, when there is much road traffic the air contains an appreciable amount of siliceous road dust which, if allowed to enter the engine with the petrol-air mixture, will have an abrasive action between the piston and the cylinder walls and the valve stems and their guides.

Tests made by the U.S. War Department upon lorry engines fitted with and without air-filters, under identical conditions of service, showed conclusively that there was *nine times* the amount of wear on the cylinder walls in the case of the engine that was not fitted with an air-filter. Further, there was *four times* the wear on the pistons, and ten times the wear on the piston rings in the latter engine. Felt type air filters were used in these tests.

Types of Air-Cleaner.—Now that the advantages of air-filters have become recognised, a number of air-cleaners of various designs have appeared on the market. These may be classified, briefly, into the following classes, viz.: (1) Those depending upon the rapid swirling rotation of the air throwing out the dust by centrifugal action.

(2) Those having filtering material through which the carburettor air is drawn. In this case porous fabrics or felts on wire or gauze supports are employed.

(3) Those that utilise the centrifugal principle in another sense, viz., by giving the dust-laden air a sudden change of direction to cause the heavier dust particles to be removed by inertia.

(4) Those depending upon the method of passing the air over oiled or greased surfaces, so that most of the dust adheres to the surfaces in question.

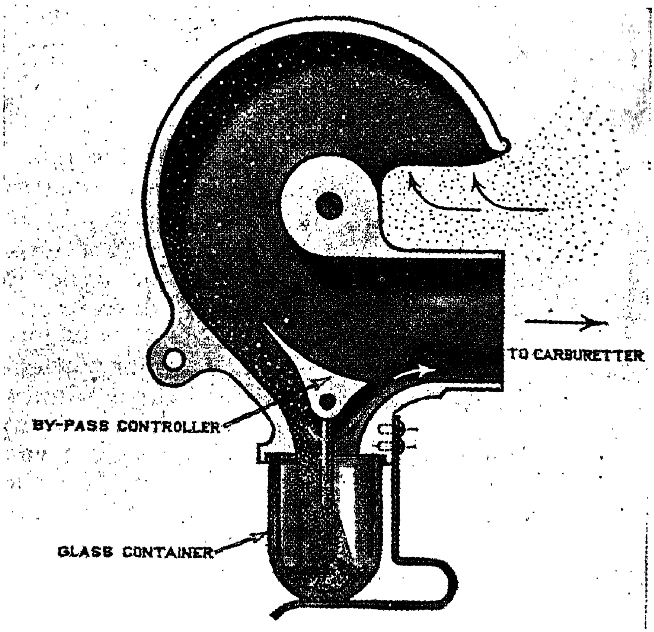


Fig. 203 —The Simms Centrifugal Air Cleaner.

The centrifugal type has the advantage of offering less restriction to the air flow, but it is not as a rule such a thoroughly effective cleaner as the felt or fabric filter type mentioned under heading (2). On the other hand, the latter type offers greater resistance to the air flow and tends to restrict the supply of air and, therefore, to limit the maximum power output obtainable.

Some of the commercial air-filters of class (2) are noisy in operation, the incoming air causing a hissing noise.

In the case of the centrifugal type it is usual to give the air its whirling motion, or rotation, by causing it to enter the cleaner through fixed radially inclined vanes or directors.

In one or two types the incoming air causes a paddle to rotate; the disadvantage in this case is that of moving parts and consequent wear in the bearings.

In certain types of tractor engines used for agricultural purposes the air is drawn through a reservoir of clear water before it reaches the carburettor; the dust in the air is removed quite effectively in this way.

Some typical air-cleaners will now be described.

The Simms Vortex Cleaner.—This simple, but effective, design of air-cleaner uses the centrifugal method of getting rid of the dust particles.

Referring to Fig. 203, the air is drawn into this device through the orifice shown in the upper right-hand side, the two arrows indicating the direction of the dust-laden air. The air is led at a fairly high velocity around the inside of the circular-shaped casing, so that the dust particles are thrown outwards and fall down the left-hand sloping side into the glass container below. This cleaner is fitted with a variable by-pass controller to alter the volume of the air flowing into the subsidiary chamber, and thus maintain a suitable air velocity for engines of different sizes and speeds. The inner surface of this cleaner's glass container can be smeared with oil or grease to trap the finest particles of dust; if the whole of the inside of the cleaner is kept greased or oiled, it will still further enhance its efficiency.

The G.M. Air-Cleaner.—An efficient and simple type of air-cleaner is shown in Fig. 204.

This cleaner belongs to the centrifugal class, the air for the carburettor entering through inclined vanes, as shown by the arrows *1* (Fig. 204). The air is thus given a swirling motion inside the cylinder *2*; this causes the solid matter to be thrown outwards as shown at *3*, whence it passes out of tangential slots provided with guides as depicted at *4*. In some cases a dust collecting retainer is mounted at *4*. The purified air passes axially in the direction shown by the spiral arrows *5*, and thence into the carburettor to which the pipe marked *6*, in the illustration, is attached.

The Protectomotor Filter.—A range of air-filters of the felt-absorption type, suitable for all kinds of internal combustion engines, is made by Messrs. Vokes, Ltd., London.

In these filters the air before entering the carburettor is drawn through felt elements (Fig. 205), having a very large total area so as to give the minimum throttling effect upon the air inflow.

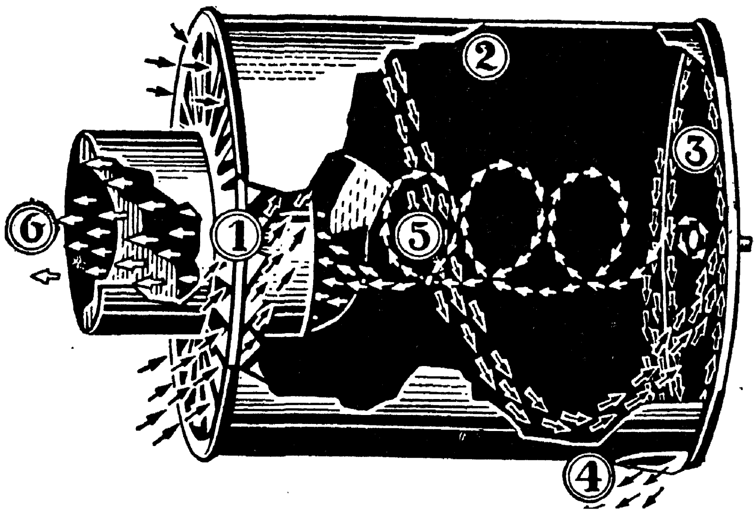


Fig. 204.—The G.M. Air Cleaner.

The outer casing is cylindrical and has a large number of slots, or louvres, cut through it. Inside this casing there is the radial-finned filter unit consisting of a felt filter medium formed in pockets over radial wire screen fins, grouped around a central cutlet; the latter is contiguous to the cast-metal outlet attached or connected to the carburettor main air inlet.

Before being placed in service the filter unit is of clean white appearance (Fig. 205, left); after an appreciable length of service it becomes dirty in appearance (Fig. 205, right).

The filter unit can readily be removed by unscrewing a butterfly screw at the top and lifting off the cap.

These filter units usually last for about 5,000-7,000 miles without attention, but, in order to maintain the best engine efficiency, they should be removed, shaken and subjected to an air-blast to get rid of most of the surface embedded dust. New filter units are obtainable for replacement purposes.

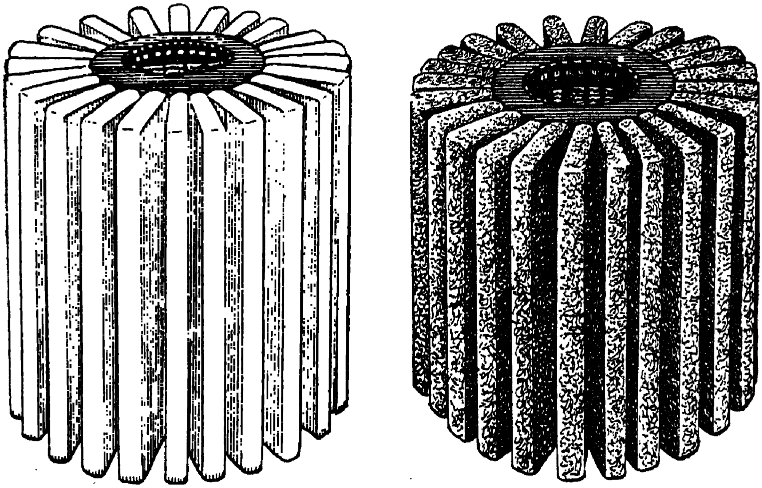


Fig. 205.—The Protectomotor Filter Element. Left, New Element. Right, Old Element.

The Smith air-filter (Fig. 206) fits over the air intake pipe of the carburettor, and is packed with a filtering medium in the form of a thick pad of wire and fabric twisted and entangled together, saturated with oil, and positioned between two grids. All solid matter in the incoming air is trapped by the filtering medium.

The gradual accumulation of foreign matter on the filter will "build up" to a point when it begins to restrict the free passage of air, as any filter worthy of the name must do. Immediately this stage is reached, air admitted through the whistle gives audible warning of the need for cleaning. This novel feature prevents any possibility of interference with the free passage of the air at any time to the engine without it being noticed by the driver.

This filter has also a silencing device to damp out the characteristic hissing noise that would otherwise be made by the inflowing air.

The Amal air-filter, Fig. 207 also belongs to the filter medium class in which any dust in the air is caught and held by a special filtering pad. In this case the cylindrical casing has a large number of openings,

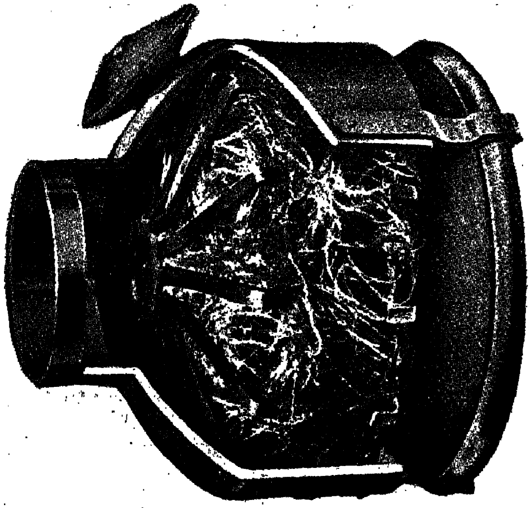


Fig. 206.—The Smith Air Filter which has a Whistle Warning Device.

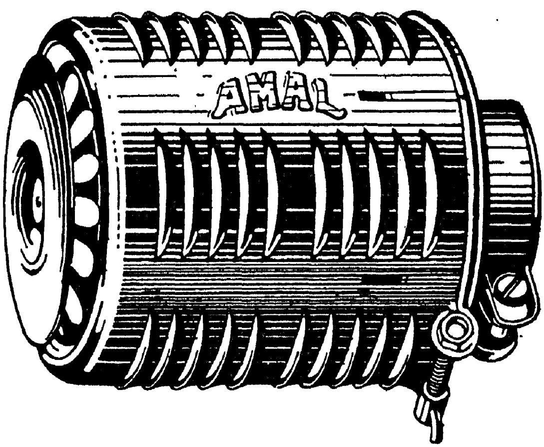


Fig. 207.—The Amal Motor Cycle Air Cleaner.

or louvres, so as to give a very large area of entry for the air; the felt filtering material also is of large area to obviate the tendency to throttle the air supply. The method of removing the felt filter for cleaning or replacement is shown in Fig. 208.

This air-filter is made in sizes and patterns suitable for both cars and motor-cycles.

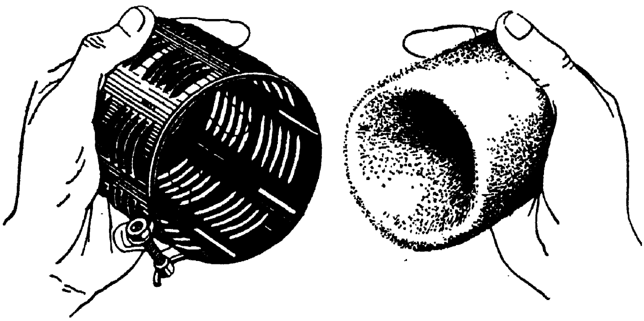


Fig. 208.—Removing Felt Filter Element of Amal Air Cleaner.

Air Cleaners and Silencers.—In the more recent motor vehicles the air cleaner also embodies a chamber or device for silencing the hissing noise usually associated with the main air intake of ordinary carburettors.

A typical example of such an air cleaner and silencer is the Burgess one shown in Fig. 209. This has been designed to suppress the various frequencies of the sounds contributing to the carburettor noises.

The compartment (A) is an acoustical dome lined with a material for absorbing the very high pitched noises. The compartment (B), known as the "hiss chamber" suppresses the noises of the ordinary high frequency so as to reduce the intake "roar". The chamber (C) suppresses the sounds of about 500 cycles, leaving only the lowest mumbles. Finally, the compartment (D) removes the latter noises, so that the whole range of noise is dealt with. Between the chambers (A) and (B) is an air cleaner, consisting of a special honeycomb winding in copper gimp; it traps the incoming air with practically no throttling effect.

Another combined air cleaner and silencer is the

United Air Cleaner shown in Fig. 210. This has an oil bath at (A), across the surface of which the intake air passes, as shown by the arrows. The dust is deposited on the oil and sinks to the bottom of the oil reservoir.

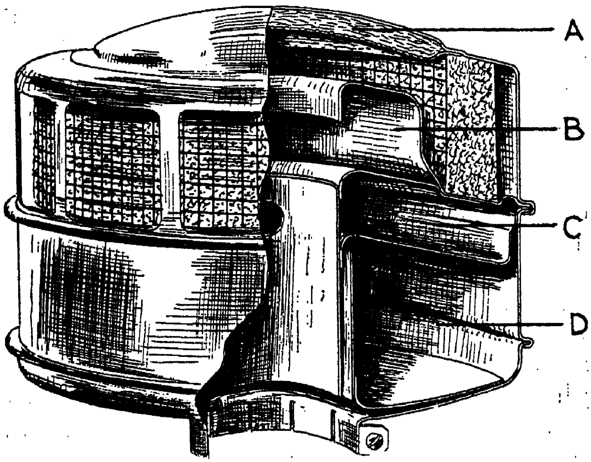


Fig. 209.—Burgess Air Cleaner and Silencer.

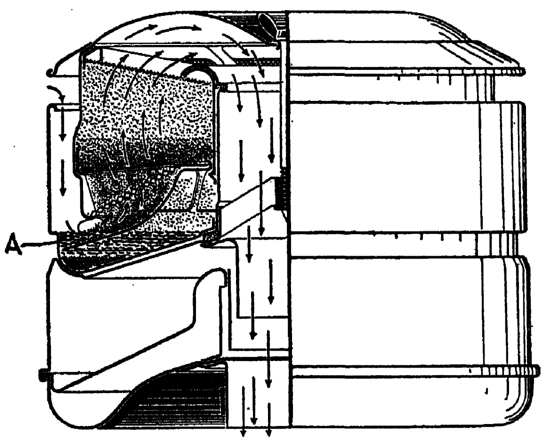


Fig. 210.—United Air Cleaner and Silencer.

The cleaned air passes upwards and then downwards through the central passage to the inlet of the downdraught carburettor; the silencer chamber is below the oil reservoir.

The commercial vehicle model holds one pint of engine oil.

The A.C. air cleaner and silencer used on certain makes of British cars is shown in Fig. 211. It has an oil-saturated air cleaner gauze (D), to which any dust in the incoming air adheres. Air entering the carburettor passes through the central tube (A). Sound waves passing out of the carburettor would also return, normally, through this tube and become audible in the car. In the present instance, however, they pass into the resonating chambers (C) and (C^1), through passages (B) and (B^1), thus setting up counter waves which damp out the original waves, to a large extent.

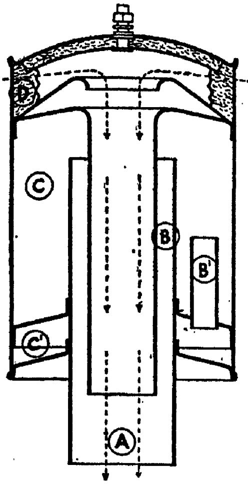


Fig. 211.—The A.C. Air Cleaner and Silencer.

The air cleaner gauze at (D) should be re-oiled with engine-oil, after cleaning it thoroughly in petrol, every few thousand miles; the re-oiled gauze should be allowed to drain before replacing it.

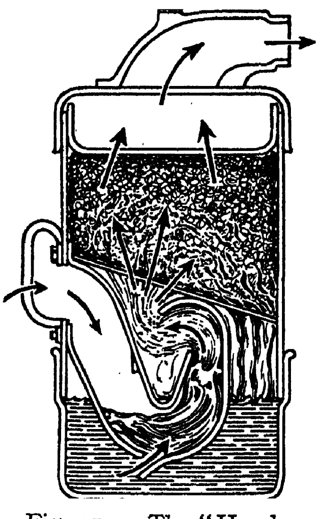


Fig. 212.—The "Handy Perfection" Air Cleaner.

An American air cleaner, known as the "Handy Perfection", is shown in Fig. 212. It belongs to the oil cleaner type, and is particularly recommended for engines operating in dusty atmospheres, such as farm tractors.

The air channel is entirely submerged in the oil reservoir, and no air can pass into the cleaner without agitating the oil in the air channel. The oil is circulated as a heavy fog in the washing

chamber, and there removes the dust and dirt from the air. The oil in the air channel is continually replenished from the main reservoir through a slot in the lower wall of the air channel. A condenser above the washing chamber traps the dirt-laden oil and returns it to the main reservoir, where the dirt precipitates and the oil becomes available for re-circulation. The reservoir holds from 2 to 4 quarts of oil and from 3 to 5 lbs. of dirt.

It is claimed that the active circulation of the oil prevents clogging of the condensing element, and the latter therefore never needs cleaning. All the operator has to do is to the clean out accumulated dirt about once a month.

The oil level rises as the dirt accumulates; the overflow of the oil is, therefore, an indication that the dirt requires cleaning out.

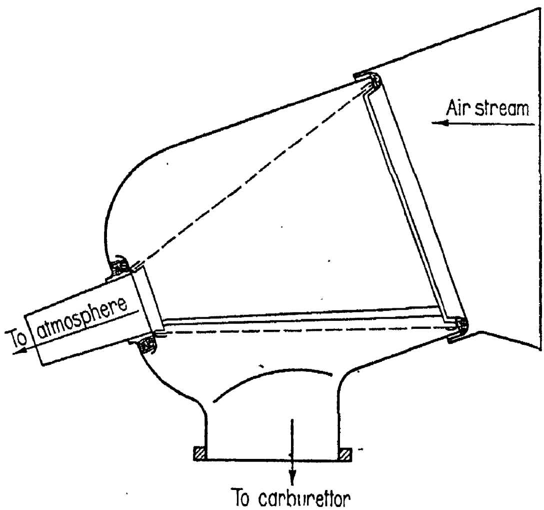


Fig. 213.—The Hirth Air Cleaner.

The Hirth Air Cleaner.—This German device belongs to the self-cleaning class and operates on the principle of a gauze cone through the larger diameter of which the air is drawn. The smaller end of the cone is left open for the purpose of allowing much of the heavier dust-laden air to pass straight through, whilst the cleaned air passes through the gauze and down-

wards to the carburettor. Any dust that may settle on the gauze is blown through the small end of the cone.

The Morris Air-Cleaner.—An ingenious method of getting rid of solid particles in the air supplied to the carburettor of the Morris and certain Wolseley engines is illustrated in Fig. 214. It consists of a large domed cover for the detachable cylinder head similar to the orthodox over-head valve cover. A horizontal partition divides the upper half of this cover into a chamber for the retention of the air-cleaning material, which consists of a quantity of curled white horse hair introduced into the cleaning chamber through two large apertures with snap-on covers. These large apertures render the removal of soiled hair for cleaning purposes or for the introduction of a fresh supply a very simple matter.

The air for the carburettor is first drawn through a series of six holes in the base of the cover situated directly opposite the plugs, which are in consequence supplied with a stream of cool air and kept at a particularly low working temperature. The air in passing the plugs and other portions of the heated cylinder head is gradually raised in temperature to a suitable extent until it is eventually sucked into the cleaning chamber through a series of small perforations at either end of the horizontal partition. At the same time it collects the crankcase fumes which are discharged into the air cleaner cover through ducts at either end of the cylinder block and in direct communication with the crank chamber. The mixture of air and crankcase fumes is finally sucked through the cleaning medium, and passes into the carburettor through an external curved pipe issuing from the centre of the cover.

It is to be noted that while the engine is working, the crank chamber and clutch chamber are entirely free from pressure, the suction through the carburettor actually maintaining a partial vacuum in these two compartments. As a result, the oil present in the crankcase and clutchcase, instead of having a tendency to be forced out past the various joint surfaces, is retained in the engine. The crankcase

fumes which are normally discharged under the bonnet and find their way into the interior of the car, are consumed by the engine and expelled with the exhaust, thus leaving the air in the interior of the car free from contamination.

The air-cleaner requires attention about once every season of use, when the horse hair should be with-

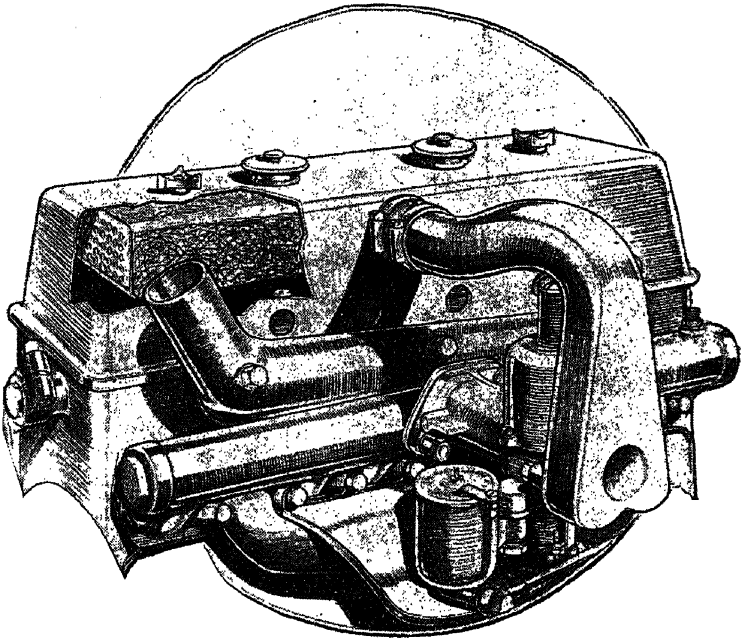


Fig. 214.—The Air Filtering and Crankcase Fume Absorption Device used on Morris Engines.

drawn from the cover through the apertures provided, carefully washed in petrol and replaced. After two or three seasons' use, fresh horse hair should be substituted.

Air Cleaner for Tractors.—Tractors which normally have to operate in dusty atmospheres are usually provided with special air-cleaning devices, which are rather more elaborate than those used on motor cars. One example has already been given in Fig. 212.

The most popular cleaner takes the form of an air washing apparatus, in which all of the air taken into

the carburettor manifold passes through a water bath, where any dirt or dust is removed.

Fig. 215 illustrates the Ford Tractor air-cleaning plant. The air supply for the carburettor is taken in from below the centrifugal pattern air cleaner shown on the right near the steering wheel. It there deposits some of its dust, the air then passing down the inclined duct—as shown by the directional arrows—to the bottom opening of the central tube shown on the left.

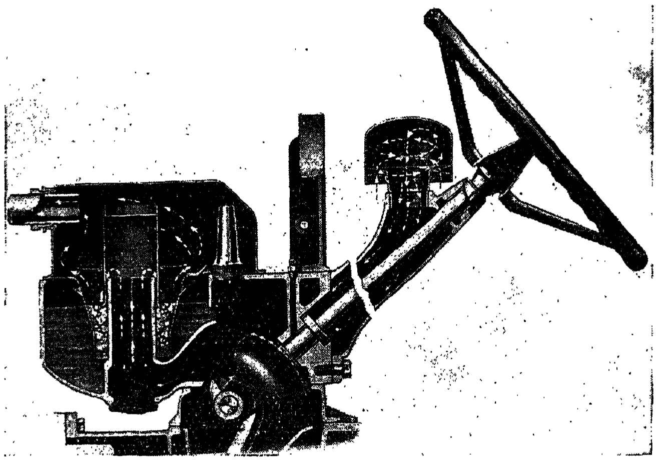


Fig. 215.—The Ford Tractor Air Filtering Device.

From here it passes upwards and then down through the annular passage, formed between the central tube and another concentric one, and bubbles through the water in the reservoir, there depositing any remaining dust. After leaving the water bath it passes upwards again, and thence through the pipe shown at the upper left-hand side, to the carburettor.

Air Intake Flame Trap.—In the past, several instances of petrol fires under the bonnets of cars have been caused by flame blow-backs through the inlet valve, inlet manifold and carburettor. For this reason gauzes were often fitted over the air inlet of the carburettor.

A better type of flame trap, however, is the Amal one, shown in Fig. 216, which is made of thin strips of non-corrodible metal layered together in a compact form, but giving a minimum resistance to air flow.

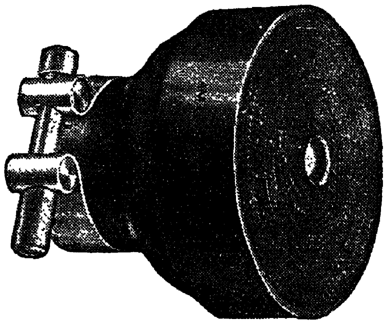


Fig. 216.—The Amal Flame Trap.

The metal strip is arranged in concentric fashion in the mouth of a funnel-shaped container, the smaller end of which fits over the carburettor air inlet orifice. The diameter of the metal strip unit is purposely made large in order to provide the full-air opening to the carburettor. This type of flame trap is also fitted to petrol tank vent pipes, fuel tank fillers, gas pipes, etc. It is employed also for aircraft engine carburettor inlets.

CHAPTER XIII

VAPORIZING THE MIXTURE

THE motor fuels of to-day often contain heavier constituents, less easily *vaporized* (i.e., converted into vapour) than the more volatile petrols of several years back. Consequently, more attention has to be given, not only to *atomization* (i.e., conversion of the fuel into a spray or mist of fine liquid particles), but also to the subsequent vaporization. Without the special means now employed to ensure the latter process, the fuel would become condensed on the walls of the inlet manifold, and give erratic running, more especially under cold weather conditions. It has been found that such fuel is ordinarily deposited in greater part where the mixture changes its path, namely, at the angles and bends.

It is therefore necessary to provide heat to the mixture to ensure vaporization. This may be done in several different ways, *viz.*, as follows: (1) By heating the main air supply. (2) By enclosing the mixing chamber in a water-jacket. (3) By exhaust-jacketing that part of the inlet pipe (or carburettor) above the throttle. (4) By locally heating part of the inlet pipe by the exhaust. (5) By exhaust-jacketing most of the inlet pipe. (6) By employing a "*fuelizer*" in the carburettor mixing chamber.

(1) Heating the Main Air Supply.—The main air intake is usually cylindrical in form and can be connected by means of a flexible metallic pipe to a sleeve surrounding the exhaust pipe at one part. This sleeve, or *muff*, is appreciably larger in diameter than the exhaust pipe, and is so arranged that all of the air flowing along the flexible pipe must pass over its surface. Fig 217 illustrates a typical hot air muff

arrangement of the type which has been used upon car engines. It is an advantage to provide a rotating sleeve, having air ports somewhere near the carburettor, so that in hot weather these air ports can be opened to admit cold air instead of hot air; otherwise the maximum power output of the engine will fall off.

Sometimes the hot air for the main supply is drawn from the valve chamber, where the latter has an enclosing plate. Heating the main air in either of these ways is usually adopted where thermo-syphon cooling is employed. In the case of horizontal model carburettors, the question of heating the mixture is usually unimportant, as there is no externally exposed inlet manifold.

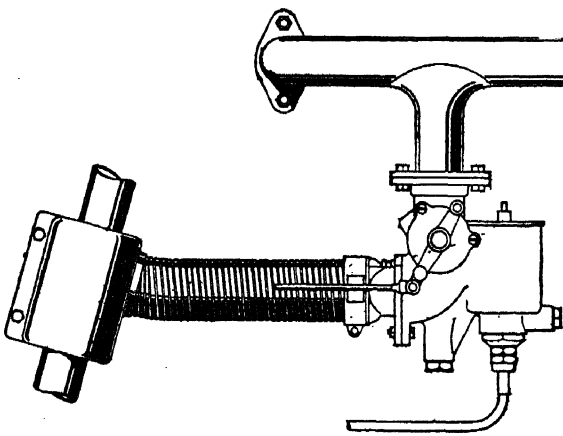


Fig. 217.—Illustrating the Exhaust Muff Method of Heating the Main Air Supply.

(2) Hot Water Jacketing.—This previously used method, which is illustrated in Fig. 218, consists in surrounding the upper part of the (vertical) carburettor, or more commonly the vertical part of the inlet pipe, with a hot water jacket, the outlet being connected with a low point in the radiator system, and the inlet to the top of the water jacket, or to the outlet pipe as shown; the pump then draws the water from the hottest part through the jacket to its own suction place. This method of heating the inlet pipe is used only where pump circulation is employed; not for

thermo-syphon cooling. Taps are generally provided to regulate the amount of heating and also to enable the carburettor to be dismounted without emptying the radiator and cylinder jackets.

Hot water jackets are much slower in action after starting than exhaust heated ones, so that for heavy fuels they do not operate when most urgently needed, namely, at starting. If a hot water jacket is desired, it may readily be fitted by winding a spiral coil of pipe tubing to the inlet pipe, and soldering the coil

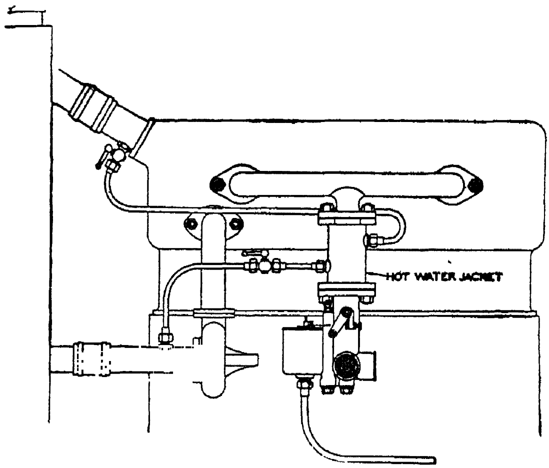


Fig. 218.—Hot Water Jacket Method of Heating the Carburettor.

to the pipe (or by running in molten lead) to obtain good metallic contact. The hot water is arranged to flow through this pipe.

Lagging the hot water jacket with asbestos will enable a higher degree of vaporization to be obtained.

Means should be provided, in the form of a draining cock, to run out the carburettor jacket water in frosty weather.

(3) Exhaust Jacketing the Inlet Manifold.—Exhaust jacketing is now widely employed. In its original application the exhaust was tapped at its hottest part (where is leaves the cylinders), and a portion of the hot gases led through a copper pipe of from 12 to 15 mm. (about half an inch) diameter to the inlet pipe jacket, and thence from the jacket through the

undershield. The pipe which was inserted in the exhaust was bent so as to face the exhaust gas stream, and at its other end was connected with the upper end of the jacket, whilst the outlet was taken from the opposite portion of the lowest sides. A tap, or preferably a screwdown cock, was often fitted for the purpose of regulating the flow of heat. The exhaust heated jacket was very quick in operating after the engine is started; this is an advantage in cold weather.

With both of the methods, (2) and (3), the vaporization is better at lower speeds (as it should be) than at higher speeds, for the mixture in the former case is in contact with the inlet pipe surface longer.

Fig. 220 shows a typical induction-exhaust pipe arrangement, used on a six-cylinder engine.

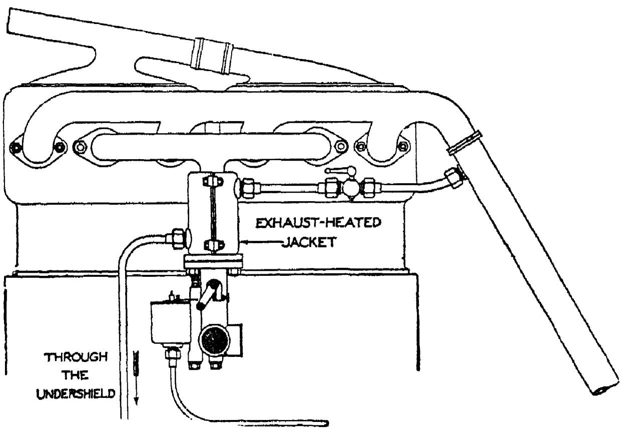


Fig. 219.—Exhaust Jacketed Inlet Manifold Method of Heating.

In this case the carburettor is bolted to the central flange, the mixture passing through the exhaust surrounded mixing chamber to the induction pipe above. The mixture then divides to each set of two cylinders.

The exhaust pipe is arranged with its connection to the exhaust manifold near the front end of the cylinder; in this position it is more effectively cooled by the air coming through the radiator.

An original method of warming the induction manifold of an engine, patented by The Daimler Company, Ltd., is shown in Fig. 221.

The water jacket (A) is provided around the induction pipe, and is connected with the cylinder cooling

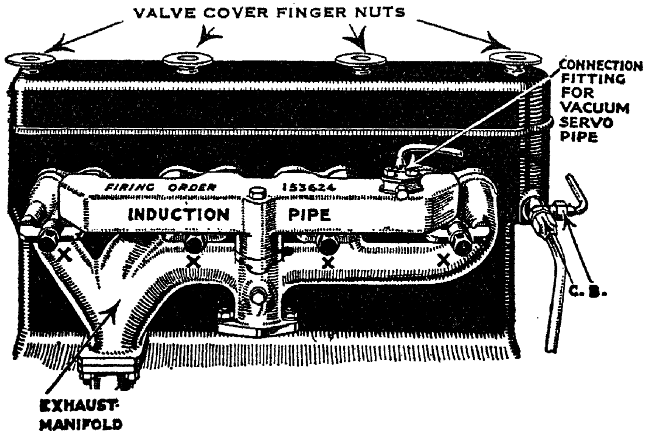


Fig. 220.—Typical Six-Cylinder Engine Induction and Exhaust Arrangement.

water system by means of the pipes (B) and (C); the water circulating pump is shown at (D). There is a thermostatically-operated valve at (E) to prevent

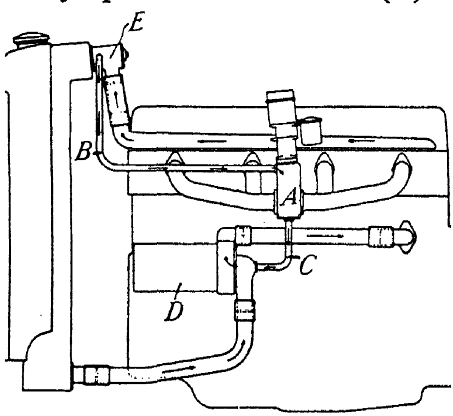
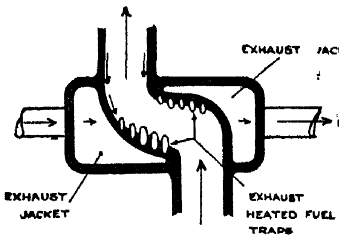


Fig. 221.—Method of Warming the Induction Manifold.

water getting to the induction pipe jacket when it becomes too hot.

(4) The Hot Spot or Local Heating Method.—Originally adopted in American engines, and when low grade fuel was employed, this system of vaporizing the fuel, which tends to condense in certain parts of the inlet system, is now used on many English engines. The principle followed in this case is to arrange that certain portions of the intake manifold are either touched by the exhaust manifold, or are directly exposed on their outer surfaces to the hot gases. Figs. 222 and 223 illustrate two typical hot spot systems. In the latter case the inlet manifold has an exhaust heated jacket at one part, and



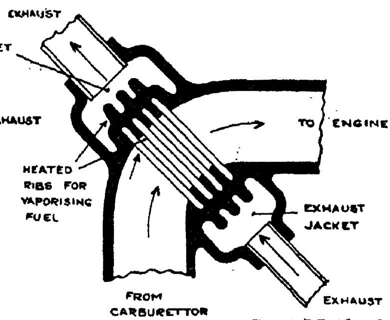


Fig. 222.—Hot Spot System. Fig. 223.—Another Hot Spot Method.

special ribs are cast on each side to expose a greater surface to the hot gases and to convey the heat better to the mixture: it will be noted that this "hot spot" is situated on the bend of the inlet manifold, i.e., where fuel deposition is most likely to occur. It is possible to "overdo" matters, however, and actually to heat the incoming mixture too much, so that loss of charge (due to the lower density of the hot mixtures results at full throttle. The results of tests made by the American Society of Automotive Engineers on certain hot spot manifolds showed that whereas ease of starting, slow running and acceleration were undoubtedly improved, the maximum horse power was reduced appreciably.

The Vauxhall Mixture Heating System.—Fig. 224 illustrates the inlet manifold employed on Vauxhall car engines, to warm the mixture before its entry into the cylinders. The contiguous portion of the exhaust mani-

fold is fitted with a bimetallic coil spring attached to the spindle of a butterfly-type valve inside the exhaust manifold. When the engine is cold the valve in question is arranged to be fully opened so that the exhaust gases are in contact with the outside surface of the inlet manifold and thus tend to heat the cold mixture

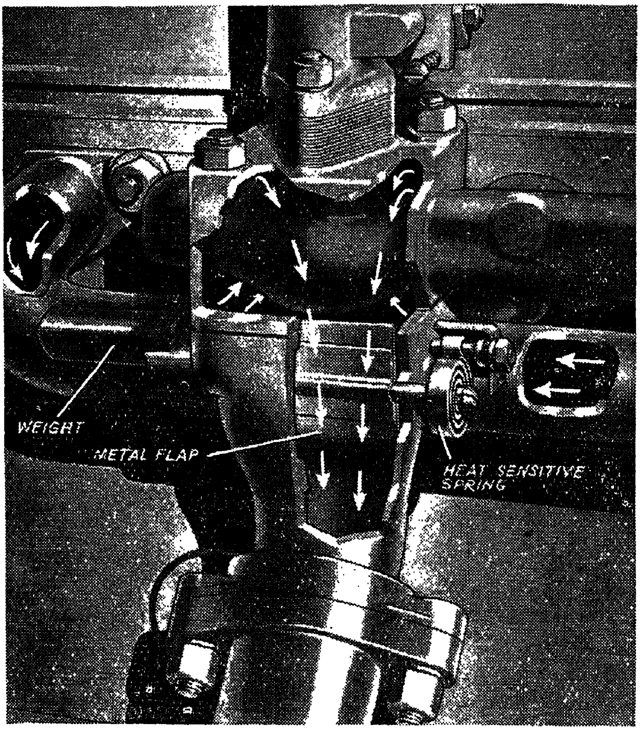


Fig. 224.—Vauxhall Exhaust Heating System.

passing through the latter from the carburettor. As the engine warms up the bimetallic element unwinds and in doing so moves the butterfly valve so as to shut off some of the exhaust gases from the inlet manifold's outer surface; the movement of the valve is arranged to provide the necessary amount of inlet manifold heating to suit the engine temperature.

Fig. 225 illustrates two interesting vaporizing devices of American design. In the lower diagram there is a tubular extension above the mixing cham-

ber of the carburettor, which is of the vertical type. The inlet manifold is concentric with this tube, and tapers down to the lowest part, which is ribbed and exhaust jacketed. Apart from vaporizing the mixture by local heating of the venturi portion of the outlet tube from the carburettor, the ribbed well portion vaporizes any of the heavier constituents of the fuel which settle on the walls of the inlet manifold and run down to the lowest part of the ribbed well.

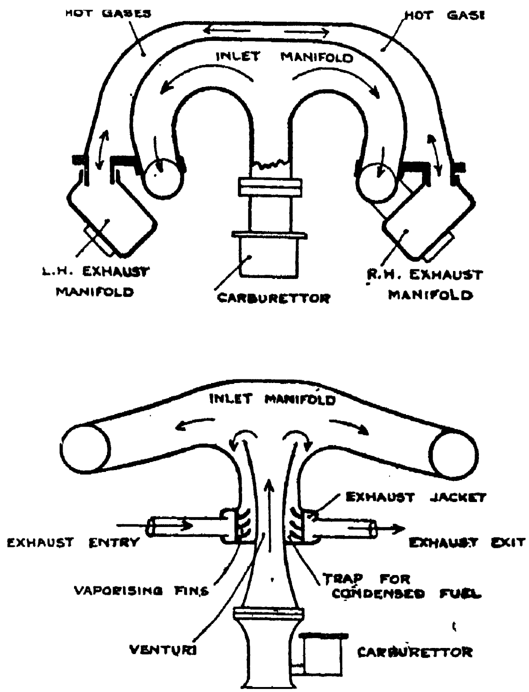


Fig. 225.—Two Examples of Vaporizing Devices that have been used on Car Engines.

A comparatively simple method of ensuring the volatization of the petrol in the mixture entering the inlet manifold from a down-draught carburettor is illustrated in Fig. 226, which shows a common connection between the lower flat surface of a well formed in the inlet manifold below the intake pipe and a similar flat surface on the upper side of the exhaust manifold. Any liquid petrol that may fall into the well is at once

evaporated by the heat conducted from the exhaust manifold, once the engine has commenced to warm up and thereafter.

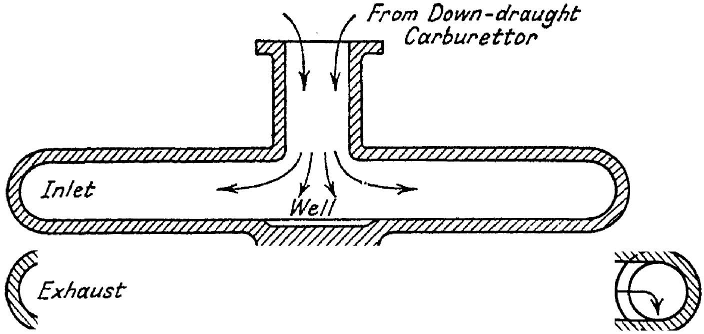


Fig. 226.—Exhaust-heated Induction Manifold Well.

Fig. 227 illustrates another method of heating the mixture by means of an externally arranged exhaust jacket. In this case there is an outer jacket surrounding the inlet pipe, immediately above the carburettor

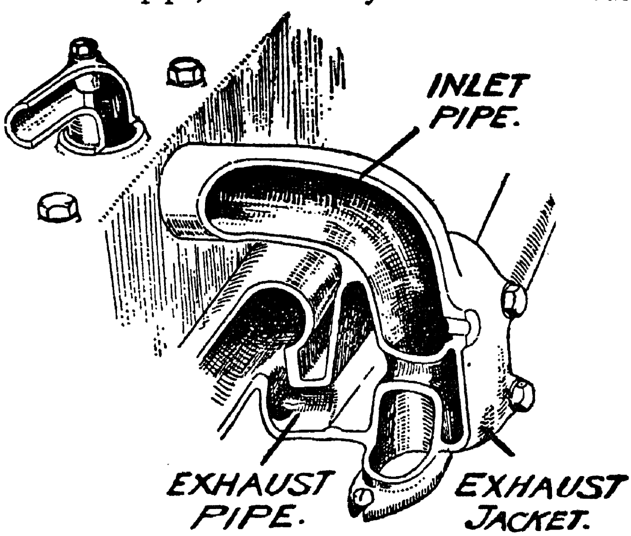


Fig. 227.—Exhaust Jacketed Inlet Manifold.

flange. Exhaust gases circulate around this jacket, and thus heat up the inlet pipe so as to vaporize, more thoroughly, the mixture as it flows into the inlet pipe.

The Austin Seven manifold shown in Fig. 228 may be taken as a good example of a modern light car engine design. This engine is fitted with a down-draught carburettor mounted above the engine, and attached at its lowest part, by means of a flange, to the one-piece inlet and exhaust manifold.

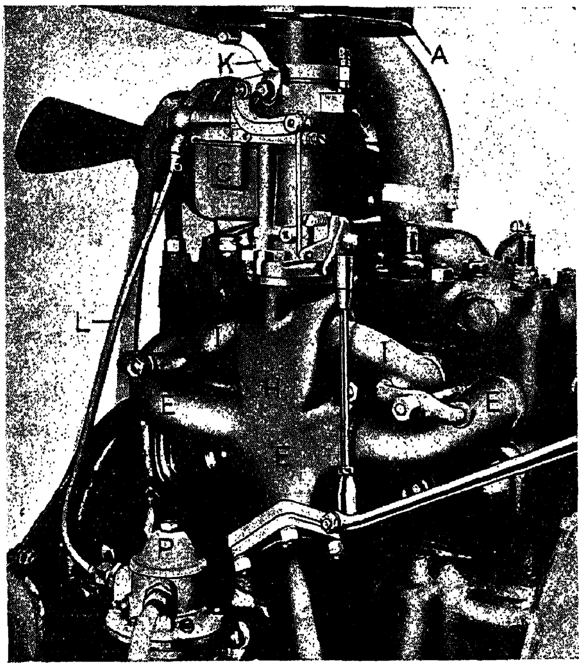


Fig. 228.—The Austin Seven Inlet and Exhaust Manifolds.
A—Air Cleaner; C—Carburettor; E—Exhaust Manifold; H—Common Portion; I—Inlet Manifold; K—Air Choke; L—Petrol Pipe from Fuel Feed Pump P.

There is a common portion (H) which serves to conduct the exhaust gas heat to the "hot spot" formed in the inlet manifold central portion. The inlet and exhaust passages are, of course, quite separate, but the exhaust heats a portion of the inlet manifold for fuel vaporizing purposes.

Fig. 230 illustrates the central part of the Chevrolet inlet manifold, which has an exhaust-heated well, in

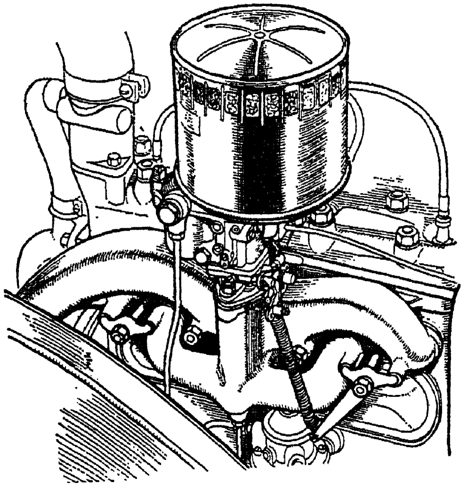


Fig. 229.—Another Inlet and Exhaust Manifold Arrangement. In this case the Exhaust is above the Inlet.

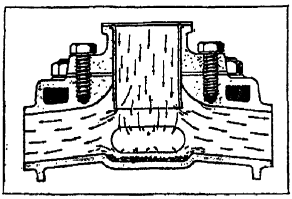


Fig. 230.—Chevrolet Inlet Manifold.

which any liquid fuel present is vaporised. The liquid fuel in question collects in this well when the engine is cold or owing to the excessive use of the air choke when starting. It will be observed that there is a shallow well below the flat oval section exhaust passage; the fuel collecting in this well is then readily vaporized.

The Packard twelve-cylinder carburettor (Fig. 231) provides conical reservoirs or "stoves", which are surrounded by exhaust-heated passages. The stoves are actually cast in the exhaust manifold directly below the carburettor venturi. The part of the inlet manifold (marked INT. in Fig. 231) adjacent to the stoves, is of large cross-sectional area, in order to reduce the velocity of flow at this point; this helps the separating out of the liquid fuel particles and their descent into the stoves, where they are rapidly vaporized. The fuel vapour then rises and enters the

inlet manifold. Any liquid which reaches the stoves before the exhaust has heated them sufficiently, remains until the stoves become hot enough.

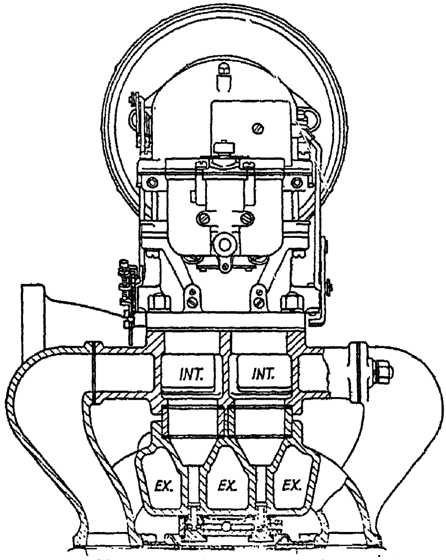


Fig. 231.—Packard Fuel Vaporizing Method.

The Opel Induction System.—The more recent Opel cars employ the hot-spot induction system, which is used in connection with a down-draught carburettor. The latter, with its mixing chamber, is mounted above the exhaust manifold, and its mixing chamber (Fig. 232) has a pocket which is exhaust-jacketed.

A thermostatically controlled butterfly throttle controls the exhaust heat to this "hot-spot" by deflecting the gases either around the latter or by-passing them into the exhaust manifold. When the engine is cold, practically all of the gases circulate around the hot-spot, but as the engine warms up the butterfly valve moves in a clockwise direction to shut off the gases.

Dual Carburettor Manifold.—The subject of dual carburettors and their inlet manifold has been referred to on page 159. It is proposed to describe another typical inlet manifold arrangement for an eight-cylinder vertical engine from the viewpoint of fuel vaporization.

Fig. 233 shows the Buick Eight inlet manifold, which is of the twin type for dual carburettor. The one branch supplies cylinders Nos. 1, 2, 7 and 8, whilst the other supplies Nos. 3, 4, 5 and 6.

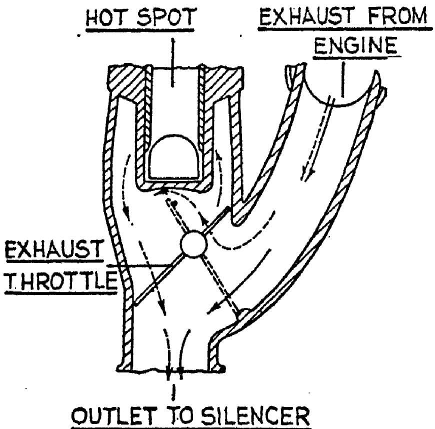


Fig. 232.—The Opel Induction System.

An exhaust jacket (A) is cast around the centre section, and is used to heat this part of the inlet manifold. It is provided with a drain directly below

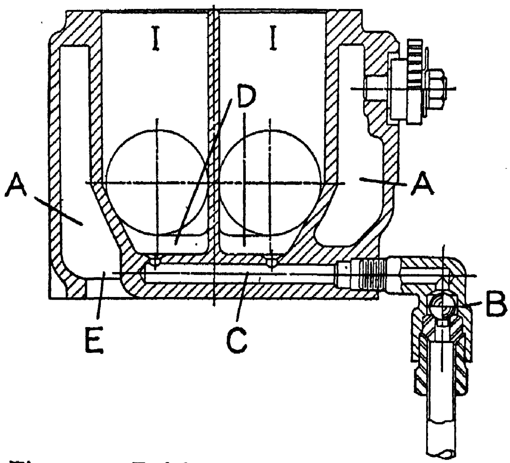


Fig. 233.—Buick Dual Carburettor Manifold.

the barrels of the carburettor to prevent an excess of liquid petrol from the carburettor, flowing into the branches of the inlet manifold.

During engine cranking operations, the fuel which falls to the bottom of the reservoirs (D), is atomized by means of a stream of air, from outside the manifold, which is drawn through the drain passages (B) and (C). This also provides a drain for liquid petrol when cranking ceases, for the non-return valve at (B) remains open when there is no suction, but as soon as the engine begins to " fire " the vacuum in the inlet manifold causes the valve to shut; it remains closed all the time the engine operates under its own power.

Any liquid fuel which then falls to the bottom of the reservoir (D), is vaporized by the heat conducted through the walls of the inner chamber from the exhaust jacket, which takes its exhaust gas supply through the opening (E).

Regulating the Exhaust Heating.—In certain instances, where part of the inlet or carburettor body is heated by the exhaust gases (by-passed for the purpose), as previously stated, it is usually arranged to control the heating effect by regulating the quantity of exhaust gas admitted to the heating chamber.

This regulation is sometimes effected by the movement of the throttle-operating mechanism and, more recently, by means of a thermostat (as in Fig. 224).

The object in view is to reduce the amount of exhaust heating as the throttle is opened, or the engine warms up.

In addition to the automatic regulation, there is often a zero position control to suit climatic conditions. Thus, in very cold weather this control would be pre-set to allow a greater amount of exhaust gas to circulate than under normal weather conditions; in hot climates, less gas would be admitted than normally would be the case.

The regulation of the quantity of exhaust gas admitted to the heating chamber is effected by means of a throttle valve of the butterfly or flap pattern, which is opened or closed by the main throttle mechanism or by a thermostatic control.

The method of regulating the exhaust gas heating in the case of the Packard Super-Eight engine is

shown in Fig. 94. The dual-pattern carburettor on the left is of the down-draught type, the two inlet pipes (I) being exhaust-jacketed. The throttle valve (V) controls the amount of heating. Thus, as shown, it is in the starting and idling position, whereby the maximum quantity of exhaust gas circulates around the jacket. As the engine is speeded up, the throttle is moved in a clockwise direction, so that eventually no gases can circulate around the inlet pipes.

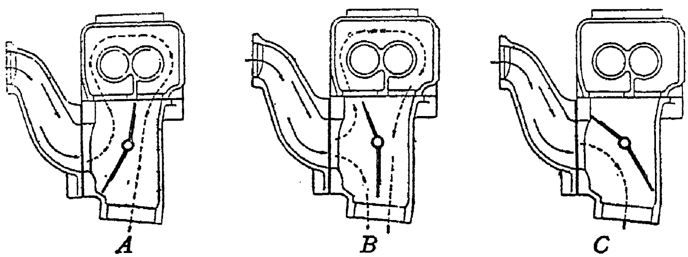


Fig. 234. The Buick Controlled Exhaust Heating of Inlet Manifold. *A*—Heat on ; *B*—Heat Medium ; *C*—Heat Off.

The Buick method of heat control is such that the centre portion of the inlet manifold is exhaust heated. The exhaust gases pass into the heat control valve body, where they strike the heat control valve and are deflected upwards into the heat jacket and around the intake manifolds. They then pass out of the heat jacket into the heat valve body, but on the opposite side of the heat control valve.

The amount of gas, and consequently of heat to the inlet manifolds, is controlled automatically by a thermostat, which governs the position of the heat control valve. It gives the maximum heating effect when in the "Heat-on" position (Fig. 234), decreasing the amount of heat as it moves to the "Off" position. The heat valve is offset, or longer on one side of the valve shaft than the other; this allows exhaust gas pressure to force the valve open when the engine is operating at full throttle.

The thermostat controlling the heat control valve consists of a bimetallic strip, wound so as to form a coil around the valve shaft, with one end inserted in a slot in the end of the valve shaft. The outer end of

the coil is hooked around an anchor stud in the valve body. The thermostat is also, to some extent, controlled by the temperature of the fan air blast, so that the heat control varies with the outside air temperatures.

Vaporizers for Heavy Oil Fuels.—In view of the recent progress of high speed Diesel type engines for road transport purposes, a certain amount of attention has been given to the subject of the use of heavy oils—such as those used in Diesel engines—in petrol engines. The employment of these fuels effects an appreciable economy in running costs, since the fuels in question cost less than petrol.

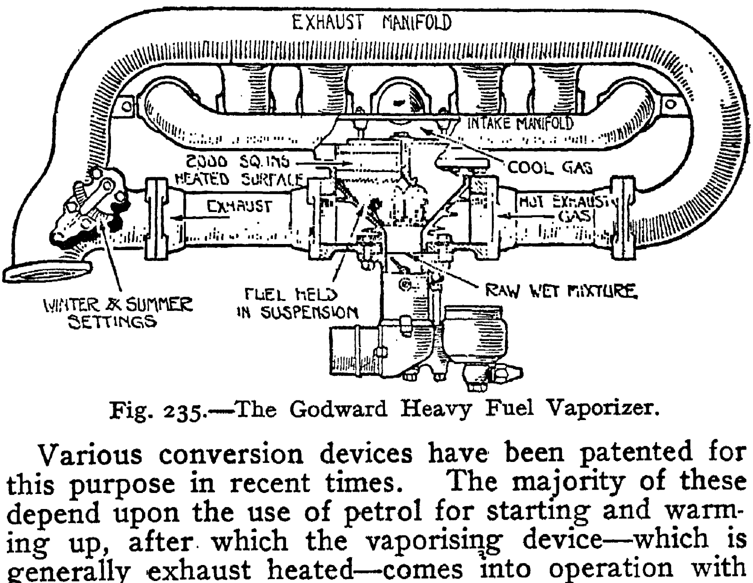


Fig. 235.—The Godward Heavy Fuel Vaporizer.

Various conversion devices have been patented for this purpose in recent times. The majority of these depend upon the use of petrol for starting and warming up, after which the vaporising device—which is generally exhaust heated—comes into operation with the heavy oil supply.

Among the more successful of these vaporisers the Watts, G.F.K., and Godward B.M.E., Heico and Hanson types may be mentioned.

Fig. 235 illustrates the Godward fuel vaporizer as used on a commercial motor vehicle engine. In this case an electric coil, consuming 8 amps. at 12 volts is used for one minute to heat the fuel to a temperature sufficient to provide a suitable mixture for the

engine. The fuel is drawn from a standard carburettor through the inside of a patent aluminium pot and over the surface of warm plates, where it is converted into a gas which passes through the intake manifold to the cylinders. Petrol is not required for starting with this invention, but in case heavy fuel is not obtainable, the vehicle can be run on petrol. Fuel

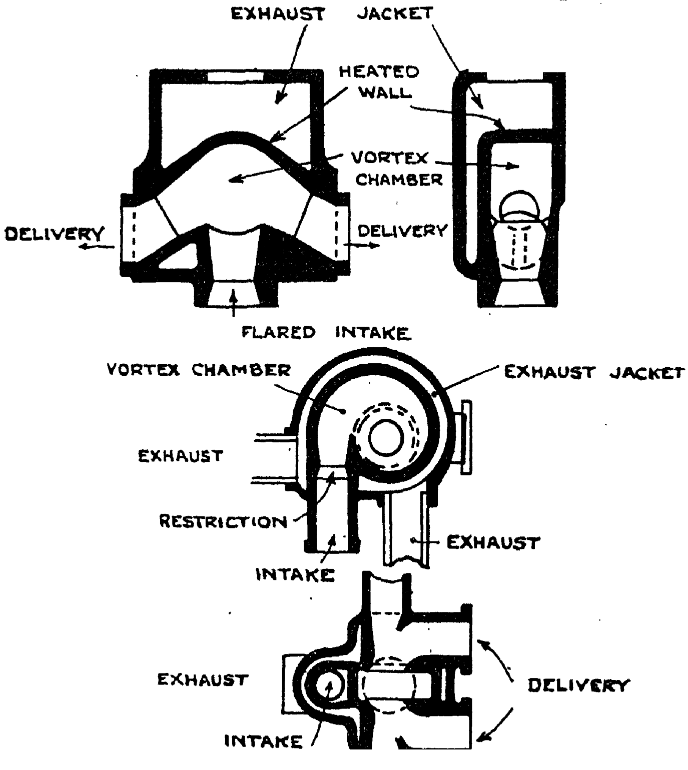


Fig. 236.—The "Drigas" System of Vaporization.

costs are said to have been reduced by about 29 per cent. and power increased by 15 per cent. Some 580 buses of the Philadelphia Rapid Transit Co. were fitted with this device. Hill climbing is better, and after 300,000 miles running (one bus) no additional wear on the engines was found.

Fig. 236 illustrates the Brewer "Drigas" type inlet

manifold, in which the atomized mixture is caused to circulate around a so-called vortex chamber, the centrifugal action causing the heavier particles to impinge on the surface of the metal, which is heated externally by the exhaust gases. It is usually arranged for a shallow recess or "puddle" at the lowest part of the "vortex chamber," in which any deposited liquid collects at low speeds, and is boiled away, or vaporized by the exhaust heat; at high speeds the increased centrifugal action causes vaporization. There is no doubt that such a system gives better vaporization, and consequently better distribution and acceleration and better results with weak mixtures, but at full

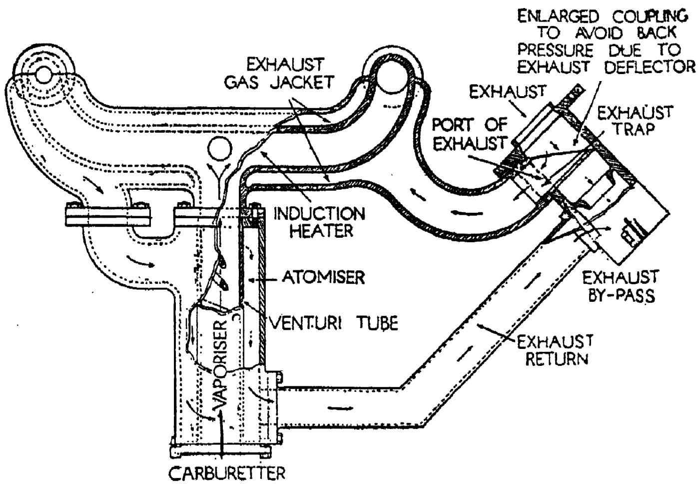


Fig. 237. The B.M.E. Heavy Fuel Vaporizer.

throttle a loss of volumetric efficiency may be anticipated on account of the increased gas friction and path changes of the mixture. The heating, as in modern American car engines, will give best results when it is under control, and regulated to suit the driving conditions.

The B.M.E. Heavy Fuel Vaporizer.—This device, of German origin, but now manufactured in this country,* has been fitted to several makes of commercial vehicle. It employs a petrol carburettor for

* Burtonwood Motor Engineering Co. Ltd., Warrington.

starting and an exhaust heated vaporizer brought into operation by a three-way change over cock; the latter embodies an oil drain position for emptying the oil from carburettor float chamber.

The method employed is to fit a special exhaust jacketed inlet manifold, in place of the normal one. This also incorporates a vaporizer; the complete unit is interposed between the ordinary carburettor and the inlet flange (Fig. 237).

A special coupling is inserted between the exhaust manifold and the exhaust pipe, from which a certain amount of exhaust gas is deflected into the jackets

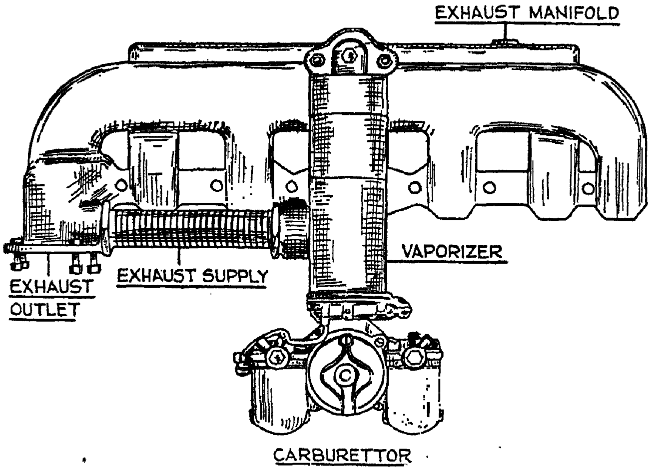


Fig. 238.—The B.M.E. Fuel System, as applied to an existing Manifold System.

of the vaporizer and induction manifold and then passed back into the exhaust system. By careful design it has been possible to avoid baffling the exhaust and creating back pressure, and, in addition, the amount of heat imparted to the induction system, coupled with the design of the passages, obviates any loss of power due to reduction in the weight of charge as a result of excessive heating of the air taken in. The vaporizer is a vertical tube with six inclined cross-tubes set spirally and open to the exhaust-gas jacket. Mixture passing from the carburettor thus passes over a large heated surface.

Once the engine is warm the supply is changed over from petrol to fuel oil and the petrol is not used except for long periods of idling. After a short stop the engine will start on the oil supply, but if it has cooled down appreciably, petrol must be used.

In the later models the change over is automatic and the supply is changed over to petrol for idling. The Zenith V-type carburettor is used.

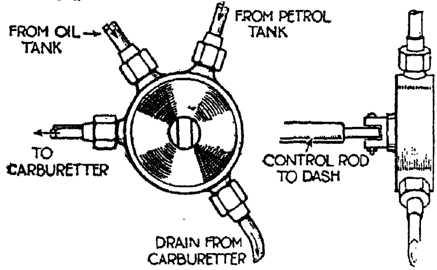


Fig. 239.—The B.M.E. Change-over Tap for Petrol and Heavy Fuel.

It is claimed that the fuel costs are reduced by about one-half, and that about 20 per cent. greater mileage per gallon is possible on fuel oil than on petrol.

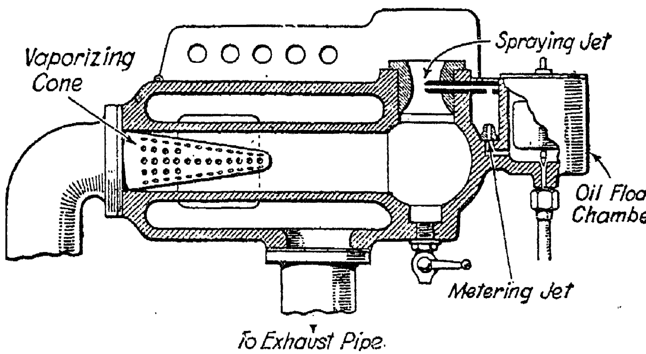


Fig. 240.—The Heico Vaporizer.

The Heico Vaporizer.—This heavy-oil vaporizer is used in conjunction with the ordinary petrol carburettor for starting and warming up. It is exhaust-heated and has a change-over valve between the petrol carburettor and inlet manifold. The valve is operated by a lever on the dashboard and the vaporizer unit throttle is connected to that of the petrol unit or to the latter's accelerator.

Referring to Fig. 240, the vaporizer has a float chamber with a metering orifice or jet and a spraying jet in series. The last-named is arranged horizontally and protrudes into a down-draught choke. Incorporated in the cast body of the instrument is an exhaust-heated jacket and, by means of a cowl, the inlet air is warmed by passing over the surface of this jacket before it enters the down-draught choke shown in the drawing on the right.

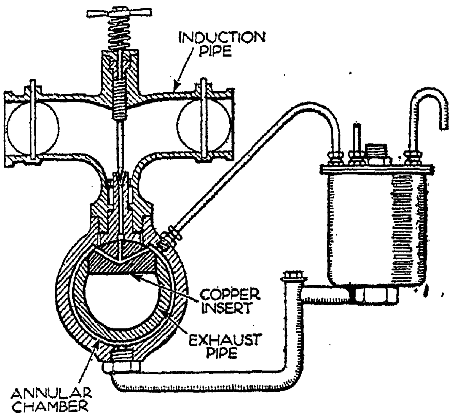


Fig. 241.—The Hansen Vaporizer.

After passing through the choke, the mixture of air and sprayed fuel reaches a chamber which is surrounded by the exhaust jacket. At the outlet end is a vaporizing cone perforated by a large number of small holes through which the mixture passes, its state of vaporization and atomization being brought more nearly to completion in this process.

To install the Heico carburettor, a hole is cut in the exhaust manifold and a flange is welded on to it. To this the Heico device is bolted and a pipe is installed to connect the outlet of the heating jacket to another part of the exhaust system.

The Hansen Vaporizer.—This belongs to the exhaust-heated class and consists of a fitting to the exhaust pipe; this has a copper insert with a number of passages formed in it. (Fig. 241).†

* *The Commercial Motor.* † *The Autocar.*

Between the member surrounding the exhaust pipe and the pipe itself there is an annular chamber to the bottom of which the fuel is led from the float chamber. The fuel is heated in the annular chamber, and it passes into the passages in the copper insert, which further heats it and assists vaporization. It then passes up past a spring-controlled needle valve in the induction pipe, where it mixes with cold air.

Should there be an excess of fuel the surplus passes in the form of gas from the annular chamber back to the top of the float chamber. When lighter fuels are to be used the copper insert in the exhaust pipe is dispensed with, and the vaporized fuel then passes directly up into the induction pipe past the valve.

This device has been well tested and is claimed to give a marked reduction in fuel costs, the sparking plugs and valves remaining in good condition over long periods of use.

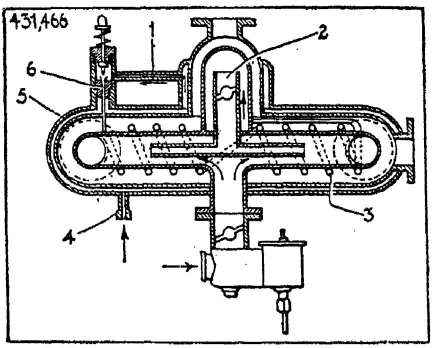


Fig. 242.—The Ehrenspeck Vaporizer.

The Ehrenspeck Vaporizer.—Another heavy oil vaporizer, of German origin, is shown in Fig. 242. It is based upon the principle that the fuel should be completely vaporized before meeting the air for its combustion. It employs the exhaust gases for heating the fuel. Referring to Fig. 242 the fuel enters at (4) and, passing first of all around a preheating jacket (5), is fed to a jet (6) *via* pipe 1. From the jet the fuel then flows through a vaporizing coil (3), after which it enters the inlet branch (2) and is drawn into the central manifold.

The carburettor at the bottom is for starting on petrol, and, in addition, is used as an air control only when running on heavy oil.

(6) Combustion Type "Fuelizers."—In this case the mixture is vaporized, more particularly at slow speeds, by trapping, or inducing a portion of the mixture into a by-pass chamber, whence it is ignited by a spark from an electric sparking-plug. The hot products of combustion are then drawn into the inlet pipe along with the unvaporized mixture which flows direct through the throttle, and the heat of combustion of the burnt gases thus vaporizes the rest of the mixture. The flame caused by the combustion cannot blow back

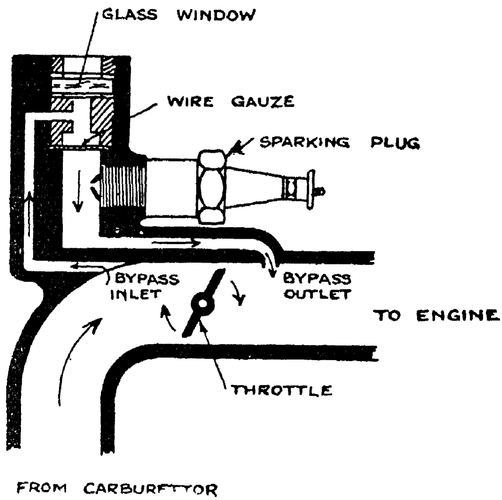


Fig. 243.—The Combustion Type Fuel Vaporizer.

into the carburettor, past the wire gauze screens provided. Earlier Packard engines used a "fuelizer" of this type to operate at small throttle openings. There was a small port leading from below the throttle to the mixture combustion chamber, and another port leading to the inlet manifold beyond the throttle, so arranged that when the latter was closed or nearly so, most of the suction due to the engine comes on these ports and mixture was drawn into the combustion chamber, when the hot gases after ignition

flowed into the inlet manifold to mix with the mixture which flowed direct. As the throttle was opened this device went out of operation.

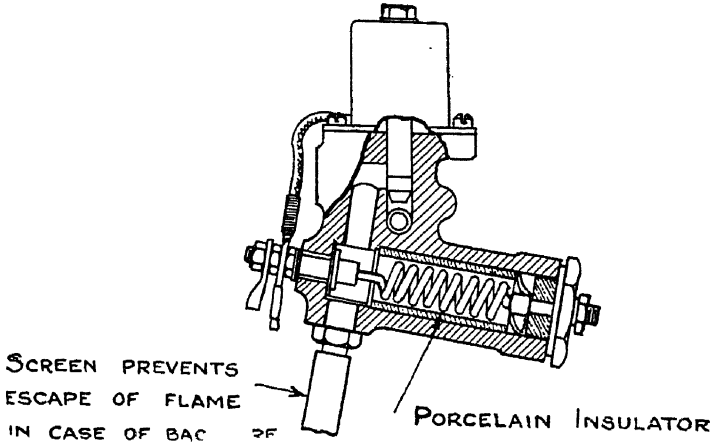


Fig. 244.—Electric Vaporizing Device which was used on the Franklin Car Engine.

Electric Vaporizers.—Another type of vaporizer employs the heat generated by the battery current

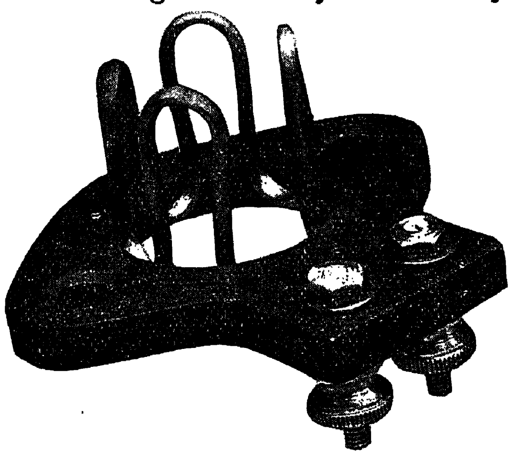


Fig. 245.—The Instarter Electric Vaporizer.

flowing through an electric resistance unit. In a typical example, incorporated in a carburettor, when the switch is closed the main air supply throttle

(or strangler) is closed by means of an electric solenoid, and current is switched on to a spiral resistance placed in a sloping tube through which a small supply of air can flow. This air supply is drawn through an air valve opened by a solenoid, when the switch above referred to is closed. The heated air is arranged to enter the carburettor above the butterfly throttle valve, where it mixes with, and effectively vaporizes, the fuel drawn direct from a jet placed in the lower end of the sloping resistance tube. Fig. 244

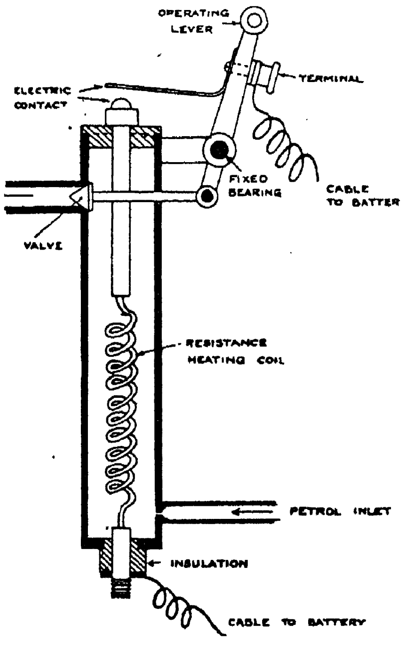


Fig. 246.—The Master Primer Electric Vaporizer.

illustrates the electric vaporizer portion of this unit.

Another type of vaporizer, known as the "Quick-Start," employs an ordinary motor headlamp type bulb, lighted by the battery current, and placed in a tube, through which the main air for the carburettor can be drawn by closing the butterfly throttle on the main inlet supply branch. The incoming air is thus heated by the electric bulb, and assists in vaporizing the fuel.

The Instarter device shown in Fig. 245 consists of a fitting bolted between the flanges of the inlet manifold and the carburettor, and provided with an electric resistance wire in the form of a grid, arranged so as to fit inside the inlet pipe. The flange is made of fibre, and acts as an insulator. Current from a 6 or 12 volt battery is switched on to the resistance element, and heats the mixture, so as to vaporize the fuel.

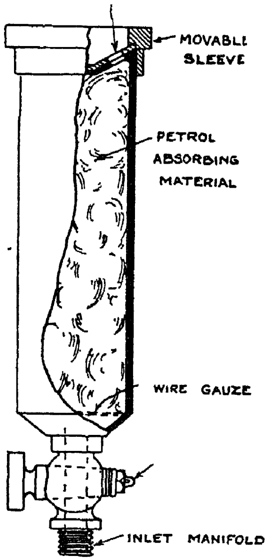


Fig. 247.—The Blake "Supplementary Carburettor."

Fig. 246 illustrates diagrammatically another electric vaporizer known as the "Master Primer," in which fuel is taken from the carburettor float chamber to the base of a closed cylinder, inside which is a helix of resistance wire. At the top of this cylinder there is an outlet pipe for the vaporized fuel to the inlet pipe, normally kept closed by a cone-valve, and also an electric contact and switch. By moving the operating lever the switch makes contact and allows the battery current to flow through the resistance, and at the same time opens the cone-valve so as to admit the heated vapour formed to the inlet pipe. This neat device is an auxiliary fitting and can be employed with any type of carburettor.

Auxiliary Starting Devices.—An interesting auxiliary device for starting purposes is the Blake "supplementary carburettor." This consists in principle of a vertical tube, provided with a tap below, and so screwed into the inlet manifold that it is vertical. At the top of this tube is an adjustable air inlet consisting of a partly rotatable cap with several holes drilled through it, and corresponding when "open" to similar holes in the metal disc below it which it turns on. The vertical tube in question is partly filled with an absorbent material which is soaked in petrol prior to starting, when the engine draws a rich mixture into the inlet manifold.

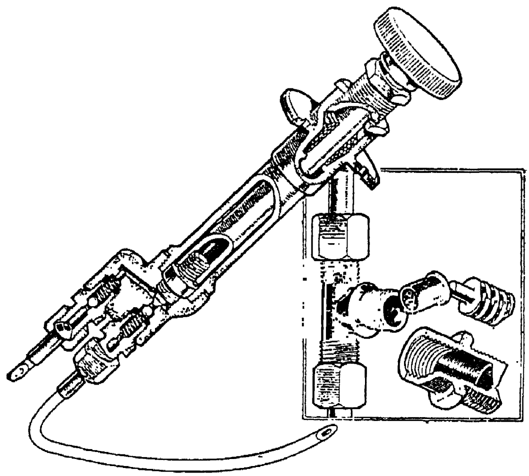


Fig. 248.—The Kigass Starting System.

The Kigass Starting System.—In this method a charge of atomized petrol is sprayed into the inlet manifold by means of a hand-operated pump mounted on the dashboard of the vehicle. The equipment consists of a small displacement pump which draws petrol from the main fuel line on its outward stroke and discharges this petrol, by means of a valve system, through special spraying nipples into the inlet manifold. This atomized petrol is drawn into the engine cylinders when the crankshaft is turned by hand or electric starting motor and forms a rich explosive mixture with the air drawn in through the carburettor.

Fig. 248 shows, in dissected view, the components of the Kigass system whilst the fuel pipe line arrangement, sprayers and hand pump are illustrated in Fig. 249.

The plunger of the pump incorporates an efficient petrol-tight packing gland and it is arranged to screw down immovably when not in use. The spraying valves are contained in elbow- or Tee-unions which are screwed into the inlet manifold in the best positions to ensure good distribution of the petrol spray to the individual cylinders. The usual positions are near the two ends of the manifold. The elbows and Tee-pieces are screwed ⅛-inch taper gas thread.

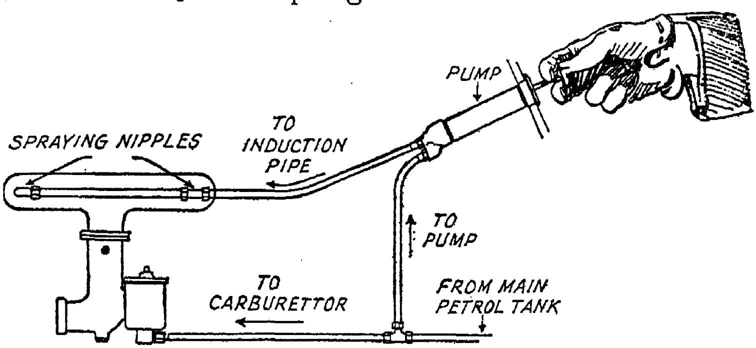


Fig. 249.—Fuel Pipe Line, Sprayer and Hand Pump of Kigass System.

In connection with the use of this device it is important not to inject more than the minimum amount of petrol necessary for starting purposes; otherwise, not only will the resulting mixture be too rich in fuel, but there is a risk of reducing the viscosity of the cylinder wall lubricant. The usual amounts for engines of 1,000 c.c. to 2,500 c.c. range from 1 to 2½ pumpfuls. *If too much petrol has been injected* the engine should be switched off, the throttle opened wide and the engine motored around a few times with the switch off. The throttle is then closed, the engine switched on and motored around without further priming.

CHAPTER XIV

FUEL FEED SYSTEMS

The fitting of the carburettor is as important as its adjustment, and certain precautions are therefore necessary in connection with (1) The position of the carburrettor. (2) The fuel supply system. (3) The inlet manifold design. (4) The heating of the carburettor or inlet. (5) The fuel filter. Items (1) and (2) are dealt with in this chapter, the others being considered elsewhere in this book.

The Carburettor Position.—With the gravity or vacuum tank system of fuel feed to the carburettor the gravity tank should be so placed that when the car is on the steepest incline, say 1 in 3, the lowest possible level of the fuel should be not less than 4 inches above the level in the float chamber in order to give a sufficient head of fuel.

With the concentric float type of carburettor the fuel level is always constant.

Referring to Fig. 250, the left-hand diagram shows the offset-float chamber type carburettor fitted to a car engine so that the line joining the jet and the centre of the float chamber is at right angles to the fore-and-aft axis of the car, i.e., the float chamber is on the right-hand or "off" side of the car. In this position the level of the petrol in the jet remains unaltered, whether the car is ascending or descending an incline.

The right-hand diagram shows the float chamber at the rear of the jet, i.e., the line joining the float chamber centre, and the jet is parallel with the fore-and-aft axis of the car.

This arrangement is incorrect for when the car is descending a hill the level of the petrol will be shown by the broken line *BB*, and the petrol will flow out of the jet. When climbing a hill the petrol level will

be as shown by the line *CC*, that is to say, the petrol will be too low in the jet and the mixture will tend to weaken.

In some cases the carburettor is purposely fitted with the float chamber in front, i.e., on the radiator side, in order to give a richer mixture for hill-climbing and a weaker mixture when descending hills.

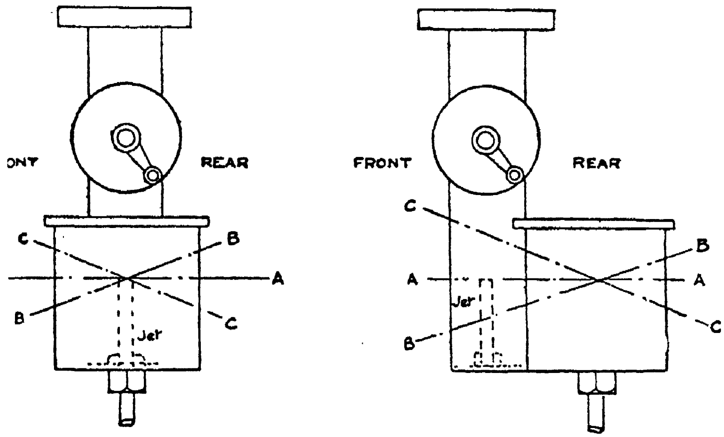


Fig. 250.—Showing (left) Correct and (right) Incorrect Carburettor Positions.

The Fuel Supply System.—The four systems of fuel supply which have been used on motor vehicles are as follows: (1) The Gravity Feed. (2) Pressure Feed. (3) Vacuum Feed. (4) Petrol Pump Feed.

Of these the first two are not now employed whilst the vacuum feed system has been replaced largely by the petrol pump one.

In the first mentioned system the fuel is contained in a tank or reservoir placed above the carburettor, and the fuel flows by gravity to the float chamber. This method, on account of its simplicity and cheapness, was once favoured on the cheaper cars. In the case of larger cars it is not convenient to place the relatively large fuel tanks required at the back of, or under the dash, as with the smaller cars, so that one or other of the two latter systems must be employed.

The fuel tank, when fitted behind the dash, may have its filler on the top (this creates a risk of

spoiling the paintwork), or an elbow, or offset filter, can be fitted on one side of the dash. It is an easy matter with dashboard tanks to arrange a direct reading glass tube fuel level indicator.

A suitably designed petrol tap, preferably of the cork-seated or screw-down type, is fitted in the lowest part of the tank, and frequently, a petrol filter is combined.

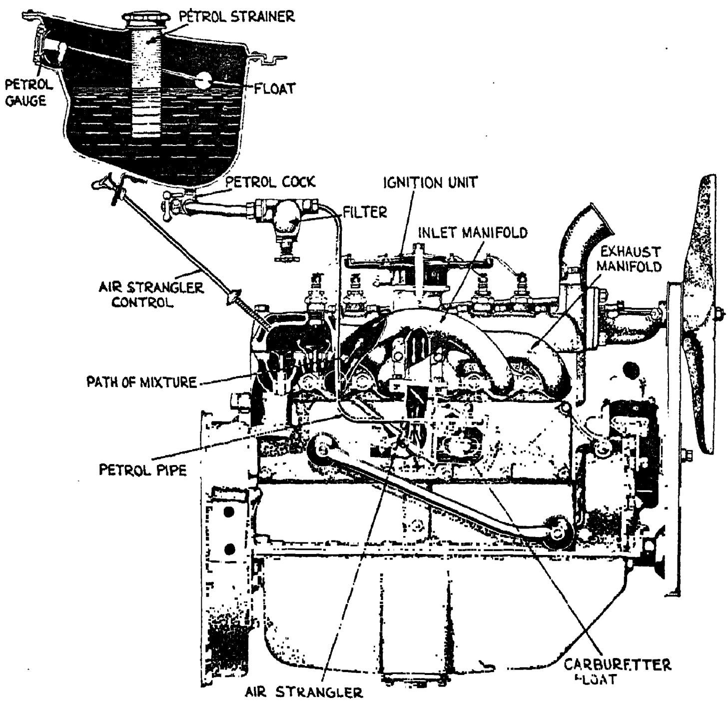


Fig. 251.—An Earlier Gravity Fuel Feed System.

PETROL PIPING

In connection with the *metal tubing* from the fuel tank to the carburettor this should be of soft copper (not nickel plated), brazed or silver-soldered to the unions; soft solder is not satisfactory for long usage, as it cracks under the constant vibration. The pipe is usually of about $\frac{3}{16}$ to $\frac{1}{4}$ in. internal diameter for cars of 10 to 40 H.P. (R.A.C. rating). It *should not*

be a straight connection between the tank and carburettor, since the relative movement between the tank and engine is likely to cause fracture of the pipe. A coil or two should therefore be arranged near the highest part of the pipe; if in the lowest or horizontal portion air-locks may be caused. Any ups-and-downs or Vees in the lowermost portions should therefore be avoided.

The petrol pipe should be held to the dashboard or chassis where necessary in rubber line clips, but should not be allowed to touch any part of the engine, chassis or dash unless it is securely clipped, otherwise the relative movement which always occurs will in time rub through the pipe. Neither should the pipe be placed near the silencer or exhaust, or the fuel will tend to vaporize and cause a vapour-lock. The petrol filter should be placed either at the tap on the tank, or immediately on petrol inlet to the float chamber, not in an intermediate position. The tank filler cap should have a small hole (about $\frac{1}{16}$ in. diameter) to allow air to flow in as the fuel is used up; otherwise there would be a stoppage of the fuel flow.

Piping for Floating Power Units.—Most modern engines are now mounted on rubber blocks at three or four places on the chassis frame and there is an appreciable amount of relative movement between the engine and frame. Since the petrol tank is fixed and part of the petrol piping leading to the fuel feed pump (in some cases the latter is mounted on the back of the dashboard) it is necessary to provide a flexible petrol pipe between the fuel feed pump and carburettor. For this purpose a braided rubber pipe made of special synthetic or petrol-resisting rubber is now employed.

(2) *Pressure Feed Systems.*—In this method, which is not now used on cars, but was once very common, the fuel tank is placed in a convenient position, low down—for example at the rear of the chassis, or under the seats—and is hermetically sealed when in use. Pressure is applied to the surface of the fuel in the tank, either by utilizing the back-pressure existing in the exhaust, or by means of a small air pump driven off the engine, so that the fuel is forced

along the supply pipe to the carburettor. As a rule, an auxiliary hand pump is fitted in a position convenient to the driver, for the purpose of obtaining the initial pressure necessary when the engine has been stopped; it is also useful in emergency. An air pressure gauge reading to about 5 lb. per sq. in. is fitted on the dashboard, to enable the driver to keep a check on the pressure in the fuel tank.

When the exhaust pressure is employed, it is arranged to actuate a spring loaded valve, so adjusted that it lifts at the usual exhaust back pressure, of 2 or 3 lb. per sq. in., and communicates this pressure to the air space above the fuel.

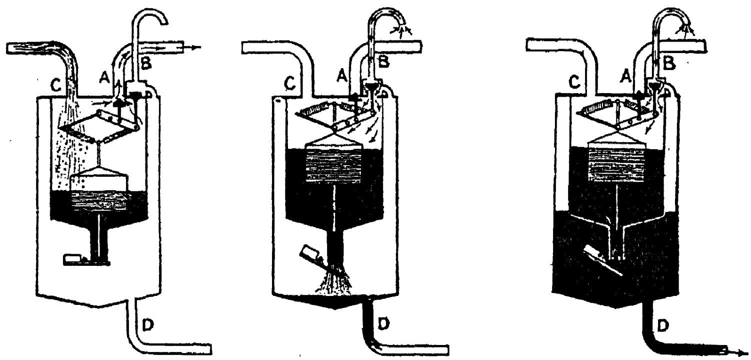


Fig. 252.—Illustrating the Principle of the Vacuum System of Fuel Feed.

Fuel tanks for use with the pressure system must be made stronger than either gravity or vacuum tanks, and the fuel filler should have an air-tight cap. The total internal load, tending to cause collapse of the tank in the case of an ordinary pressure tank, is of the order of 1½ to 2 tons. The air pump pressure system is considered better than the exhaust pressure one, as it is more positive and reliable.

(3) *Vacuum Feed Systems*—The vacuum feed system largely supplanted the pressure feed on later motorcars on account of its reliability, and due to the fact that the main fuel tank is left open to the atmosphere as with the gravity system, so that it does not require to be so strongly made.

The vacuum feed system, although now largely replaced by the fuel pump one on motor-cars, is still employed on many commercial vehicles of both the petrol and Diesel engine class.

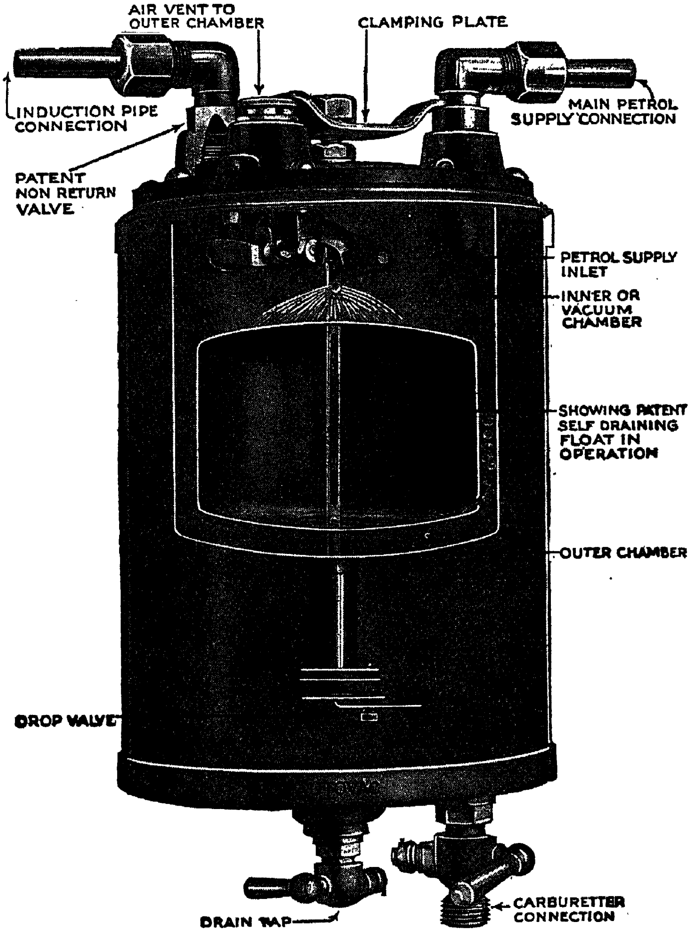


Fig. 253.—The Self-Draining Autovac Fuel Feed.

The principle of the system consists in utilizing the partial vacuum which exists in the inlet manifold to "suck" or draw up fuel from the main tank into a small capacity auxiliary fuel tank, usually on the back of the dashboard, whence it flows by gravity to the carburettor.

This auxiliary tank is provided with an automatic device which puts the space above the fuel in communication with the atmosphere as soon as the fuel level rises to a given position, so that the fuel can flow by gravity in the correct manner. The Stewart and Autovac are typical examples of vacuum feed systems. The principle of these systems can best be followed by reference to the line diagrams of Fig. 252. Here, A indicates the vacuum pipe from the induction manifold. B the air vent, with direct communication to the outer vessel, and connection with the inner vessel when the valve shown is lifted by the inner vessel's float. C is the fuel feed pipe from the main fuel tank, and D is the fuel feed to the carburettor. In the first diagram the outer vessel is empty and the inner vessel is filling in virtue of the partial vacuum in the pipe A, which is opened by the float operated valve shown, being open. Fuel is thus drawn into the inner vessel. When the fuel reaches a certain level in the inner tank its weight operates a "drop" valve and allows the fuel to flow into the lower chamber; at the same time the atmospheric valve at B is opened, and the suction valve in A is closed. As the fuel flows into the lower vessel the float again drops, opening the suction valve and closing the atmospheric valve; this cycle of operations is then repeated as the fuel in the lower vessel is used up by the carburettor.

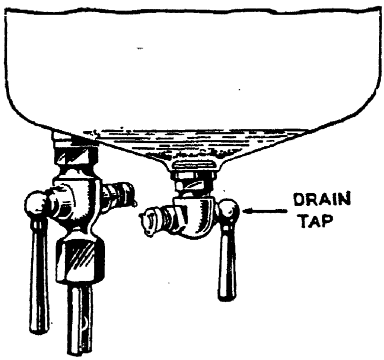


Fig. 254.

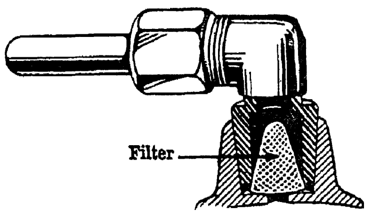


Fig. 255.

Fig. 253 illustrates the self-draining Autovac type of vacuum feed which works on the same principle as previously explained, but provides in addition a simple

means for ensuring that the float will operate, even when it is punctured. A hollow stem is fitted to the float in which are drilled two holes, one at the bottom of the stem *inside* the float, and a corresponding hole at the top of the stem *outside* the float. If fuel should leak into the float it will automatically be evacuated from the float during the suction period of the apparatus. During the periods of atmospheric pressure air will flow into the float to take the place of the evacuated fuel, so that the float will function is if air-tight.

The sediment trap in the base of the outer chamber is shown in detail, in Fig. 254, whilst the gauze filter cone in the petrol supply pipe elbow is given in Fig. 255. It is important when reassembling the latter to see that the gauze cone is always replaced with the point upwards.

A Typical Fuel System.—An example showing the carburettor, inlet manifold, petrol filter, air-cleaner and vacuum feed tank is shown in Fig. 256, illustrating a car fuel feed system.

This illustration shows the carburettor (A) with the air-cleaner (B), which removes all dirt; the vacuum tank (C) with visible glass type petrol filter (D), inlet manifold (E), and the vertical pipe (F), connecting the carburettor with the inlet manifold. Exhaust gas enters at the rear of this pipe (F) and goes out at (G), heating the gas to a proper temperature as it rises from the carburettor to the inlet manifold. In this system, as previously described, the heat is regulated automatically according to the speed of the engine. There is more heat in starting at low speed and less heat as the speed increases. This prevents overheating of the vapour before it enters the cylinders.

Petrol Pump Feed to Carburettor.—The vacuum feed system for supplying petrol to the float chamber of the carburettor has more recently been replaced by the petrol pump method. This latter system dispenses with the use of a partial vacuum, and in its place utilizes a small petrol pump, driven either mechanically, from some moving part of the engine,

or electrically, using the current from the battery. These pumps take up but little space as compared with the vacuum tank unit, are independent of the suction in the inlet pipe, and are fool-proof. The vacuum system is not altogether reliable, for when the engine is running at a low rate of revolution

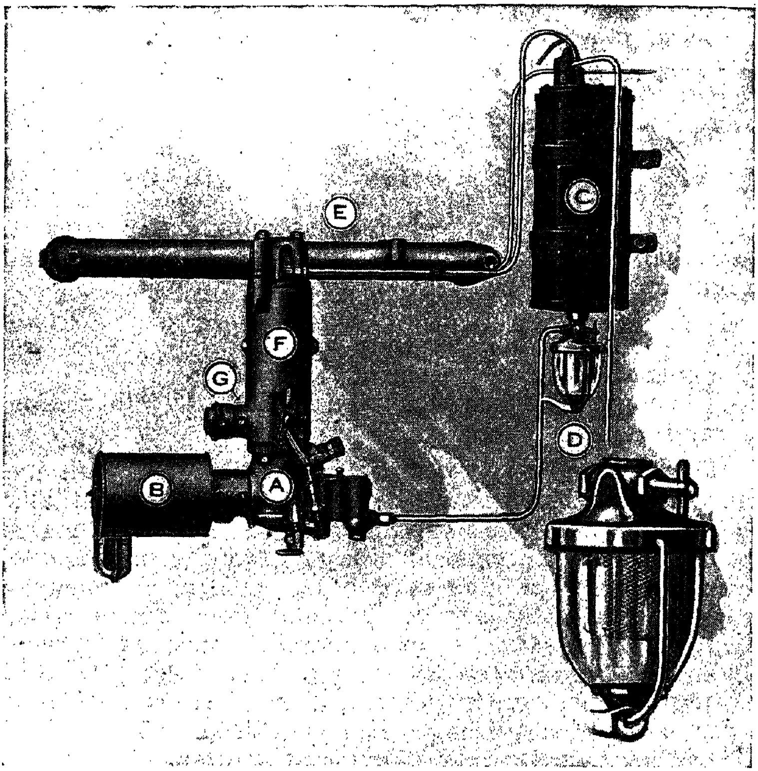


Fig. 256.—Typical Car Vacuum Fuel Feed Arrangement.

for long periods with generous throttle opening—as when climbing long hills, there is practically little suction in the induction pipe, so that the vacuum tank may, in time, be drained. This state of affairs happens occasionally when long gradients have to be climbed. The petrol pump, on the other hand, always supplies petrol to the carburettor in proportion to the engine

speed, and as the modern pump is always set to deliver *more* petrol than is actually required, the excess being returned to the petrol tank, there is always a balance for emergencies, such as when starting up, or in the event of leakage occurring.

Petrol pumps usually draw their petrol from the rear petrol tank through a gauze filter in the pump

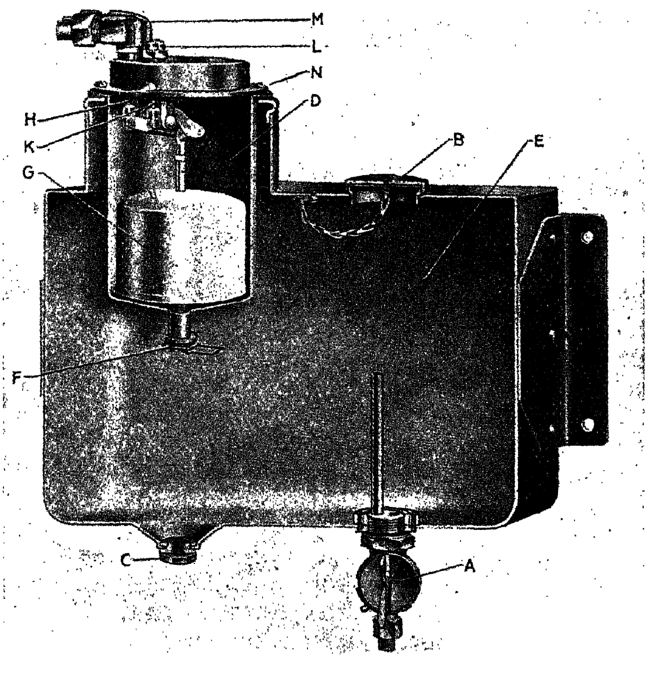


Fig. 257.—The Leyland Commercial Vehicle Diesel Engine Autovac System.
A—Fuel Tap to Fuel Injection Pump; *B*—Filler Orifice; *D*—Vacuum Tank Float Chamber; *E*—Fuel Tank (gravity); *F*—Outlet to Fuel Tank; *G*—Float; *H* and *K*—Fuel Inlet and Air Valves; *L*—Air Vent; *M*—Fuel Inlet from Main Tank; *N*—Securing Screens for Cover.

unit, and thence to the float chamber of the carburettor. Any excess pressure causes a ball valve to lift, so that the surplus petrol passes back into the main tank, or circulates it round again.

Modern petrol pumps usually work at 1 to 2 lbs. per sq. in. pressure, and are so efficient that they commence to pump at engine cranking speed.

The electrical type of fuel pump employs a solenoid magnet, energised from the car starting battery, and provided with a make-and-break contact, so as to obtain an intermittent movement for the piston, or diaphragm, giving the pumping action.

Location of Fuel Pump.—The fuel pump should be mounted away from the exhaust manifold or other hot part of the engine; otherwise vapour lock troubles may occur. Its best position is, preferably at a level below the carburettor when it will feed a uniform flow of fuel to the latter without any surging effects.

When deciding upon the position of the fuel pump the question of ready access to the fuel filter and hand primer should also be considered.

Electric Petrol Pump.—A good example of a modern electric pump is that known as the Petrolift (made by the S.U. Company), shown in Fig. 258.

The mechanism consists of a metal tube which contains a hollow iron pump plunger, which is lifted by a solenoid wound outside the tube. The iron plunger contains a disc valve and there is a foot valve at the bottom of the metal tube, so that the action is that of an ordinary lift-pump. The solenoid draws the hollow iron plunger upwards, thus drawing petrol from the main tank and at the same time lifting the petrol above the plunger into the upper part of the container. When the contact is broken, the plunger falls by gravity and the petrol drawn from the tank passes through the valve to the upper side of the plunger, ready for the next lifting movement.

An ingenious mechanism serves to make and break the contact for current to the solenoid. Above the head of the plunger and normally in contact with it, there is a light sleeve of iron to which is attached a piston rod. The piston rod passes through a cork float and has a boss on the end, so that the rod can slide upwards through the centre of the float, but if the float rises as high as the end of the rod, it carries the rod and piston with it.

The light iron sleeve serves to complete the magnetic circuit between the poles of two small permanent magnets which are placed around the tube. Outside the tube there is also a rocking device of iron, which carries the contact point. When the iron sleeve is at the lower end of its stroke it completes the magnetic circuit between the lower poles of the

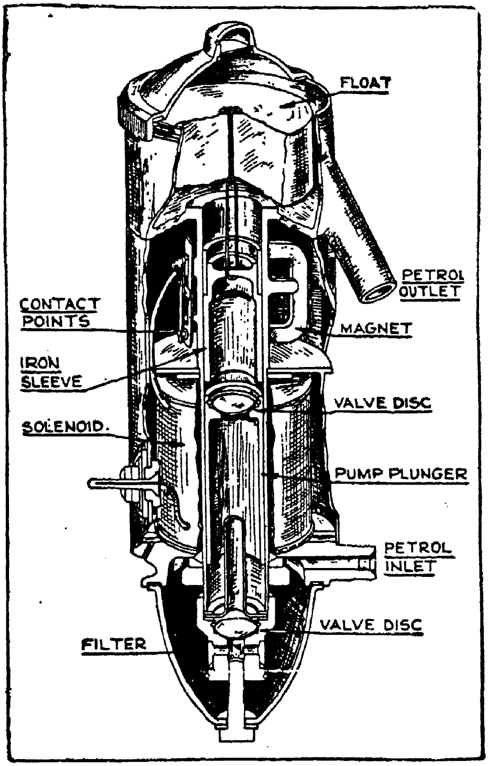


Fig. 258.—The Petrolift Electric Petrol Pump.

permanent magnets, so that the upper poles are free to attract the rocking device, which then swings over and makes the contact. Thus, the solenoid is energised and the plunger rises, carrying the iron sleeve with it, which in turn completes the magnetic circuit between the upper poles of the permanent magnets and allows the rocking device to be attracted by the lower poles, so that the circuit is broken. So

the cycle of operations is continued until the cork float rises and holds the iron sleeve in the upper position, thus keeping the contacts open. When the fuel flows through to the carburettor, the float falls and the operation of pumping begins again.

The reservoir holds only a small amount of fuel. The device can be switched off when the engine is not running by means of the ignition key switch, if desired. The pump is capable of delivering 10 gallons per hour, and it consumes 0·8 watt of electricity per gallon per hour.

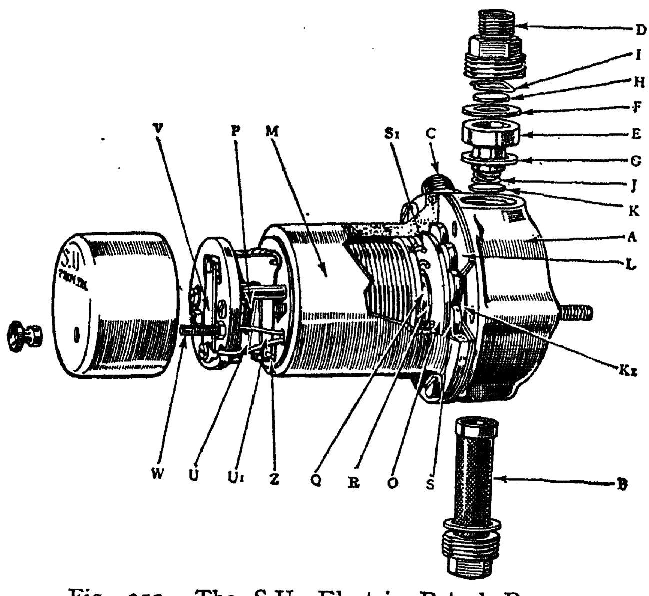


Fig. 259.—The S.U. Electric Petrol Pump.

The S.U. Pressure Pump. — This electrically-operated fuel pump is widely used on British cars, including the Morris and Wolseley ones; it is neat and of compact form.

Referring to the partly cut-away view given in Fig. 259, the pump has an electro-magnet (R) which attracts a steel armature (O) connected to the pump diaphragm (L); the electrical circuit is made and broken by the movement of the armature.

The pump consists of three main assemblies—the body, the magnet assembly, and the contact breaker. The body is composed of a hollow brass stamping (A) into the bottom of which the filter (B) is screwed. The inlet union (C) is screwed in at an angle on one side. The outlet union (D), which is screwed into the top, tightens down on to the delivery valve cage (E), which is clamped between two fibre washers, (F) and (G). In the top of the cage is the delivery valve, a thin brass disc (H) held in position by a spring clip (I). Inserted in the bottom of the cage is a light spring (J), which rests on the suction valve (K), the latter being a similar disc resting on a seating machined in the body. Holes connect the space between the valves to the pumping chamber, which is a shallow depression on the forward face of the body. The space is closed by a diaphragm assembly (L), which is clamped at the outside between the magnet housing (M) and the body, and in the centre between a brass plate (K1) and the steel armature (O). A bronze rod (P) is screwed through the centre of this and passes through the magnet core to the contact breaker, which is located at the far end.

The magnet consists of a cast-iron pot having an iron core, on which is wound a coil of copper wire which energises the magnet. Between the magnet housing and the armature are fitted eleven spherical-edged brass rollers (S). These locate the armature centrally within the magnet at all times and allow absolute freedom of movement in a longitudinal direction.

The contact breaker consists of a small bakelite moulding carrying two rockers (U) and (U1), which are both hinged to the moulding at one end, and are connected together at the top end by two small springs arranged to give a "throw-over" action. A trunnion is fitted into the centre of the inner rocker and the bronze rod (P) connected to the armature is screwed into this. The outer rocker (U1) is fitted with a tungsten point which makes contact with a further tungsten point on a spring blade (V). This spring blade is connected to one end of the coil and the other

end of the coil is connected to the terminal (W). A spring (S_1) is interposed between the armature and the end plate of the coil.

Tracing Troubles with the S.U. Pump.—Apart from the occasional removal and cleaning of the fuel filter in the bottom of the pump body, very little attention is needed. In the event of any trouble occurring, however, should the pump be suspected, first disconnect the pump union of the pipe from the pump to the carburettor and switch on the ignition. If the pump functions, the shortage is due either to blockage of the petrol pipe to the carburettor, or possibly to the carburettor-float needle sticking up. If the pump will not function after this has been done, first remove the filter, which is held in position by the brass hexagon nut at the base of the pump, and see if this is clear. Then disconnect the petrol pipe leading to the tank and blow down this with a tyre pump to ensure the pipe being absolutely clear, and reconnect the petrol pipe.

If the pump still does not function or only works slowly, the stoppage may be due to a bad earth return. To test for this, make definite metallic contact between the brass body of the pump and the car chassis with the length of copper wire fitted. To ensure a good earth it may be necessary to scrape off a small portion of the black enamel with which the chassis is coated. If the pump then functions normally, the copper earth-wire connections should be cleaned and re-made.

A bad connection in the pump itself may sometimes be traced to the nut on the terminal inside the cover not being screwed down firmly.

Should these points be found in order but the pump still does not work, the trouble is in the pump itself and the cause will be too much tension on the diaphragm or blackened contact points, the cause of which is the tensioning of the diaphragm. The remedy is to remove the cover from the contact points and pass a piece of thin card between the points when pressed together, so as to effect the necessary cleaning.

To release the tension on the diaphragm, remove the body from the base of the pump by undoing the small

screws which hold these two parts together. The diaphragm itself will then be found to be adhered to the body of the pump, from which it will have to be separated. A knife will help in this operation, care being taken to prevent the rollers which support the diaphragm and act as a bearing from falling out. The body should then be replaced on to the base, and the screws put in loosely, but before finally tightening up it is advisable to stretch the diaphragm to its highest possible position. This is effected by switching on the pump and holding the contact points together while tightening the screws well up. This will effect a permanent cure.

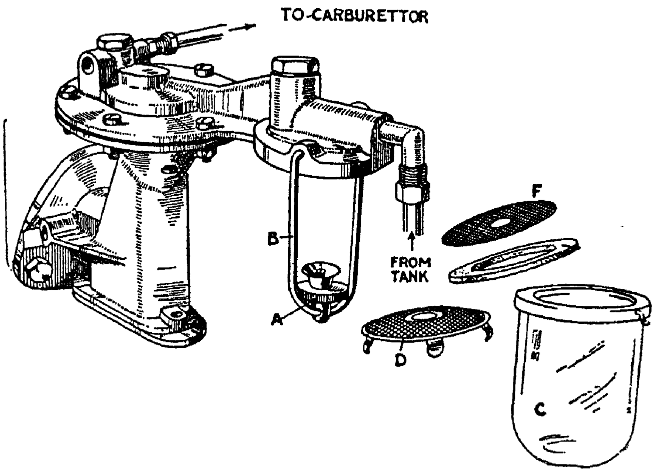


Fig. 260.—The Combined Petrol Pump and Filter used on Armstrong-Siddeley Engines.

If the pump becomes noisy it is a sign that an air leak has developed on the suction side; all joints and unions should then be examined for tightness.

Failure to deliver petrol is usually caused by dirt becoming lodged under one of the valves.

The Combined Fuel Pump and Petrol Filter.—Fig. 260 shows the combined unit fitted to Armstrong-Siddeley engines. In this case, the combined mechanical type petrol pump and filter are held to the nearside of the crankcase by screw bolts and

spring washers, the face joint being made of paper. The eccentric on the camshaft operates a cranked arm and plunger which actuates a linen diaphragm. When this moves in one direction it sucks petrol from the tank through the filter cup and its gauzes. When it moves in the opposite direction it forces the fuel into the carburettor. The filter cup C consists of a glass bowl which can be removed by loosening the milled disc nut A at its base and then swinging its supporting stirrup B to one side. The two gauzes D and F in the aluminium head can then be removed and cleaned.

Occasionally, say after each 2,000 miles running the cup of the filter should be removed and any sediment or water therein cleaned out. At the same time the gauzes should be carefully wiped with a piece of linen cloth to remove any fluff or foreign matter that may have become deposited on them.

While in this design of filter the tendency is for any foreign substance in the fuel to settle at the bottom of the cup, the gauze should not be neglected indefinitely on this account. A partially choked petrol filter gauze is sometimes responsible for erratic running of the engine. If the fuel does not flow through the filter freely it may not reach the carburettor sufficiently fast to meet the requirements of the engine. Misfiring and "hesitation," which may be accompanied by "popping" in the carburettor, when the engine is running at medium and high speeds either on the level or on hills, are often due to a partially choked filter gauze.

The A.C. Fuel Pump.—This was one of the first mechanical petrol pumps to be used on motor-cars and it has, since its inception, been improved to a high standard of reliability. Fig. 261 shows the model fitted to Standard cars. The pump is operated by the camshafts and works on the flexible diaphragm principle. It is mounted on the side of the engine crankcase.

Petrol flows to a strainer before passing through the non-return inlet valve. The pump chamber contains a non-return outlet valve and at the lower end a diaphragm operated by a pull rod from the

rocker arm which is in connection with the lever. The rocker arm constantly oscillates, and if the pump chamber is full of petrol, causing the diaphragm to be depressed, the rocker arm works freely and does not operate the diaphragm. The spring behind the diaphragm provides a constant pressure of fuel to the carburettor float chamber and thus the stroke of the diaphragm is automatically governed to meet the requirements of the carburettor. The rocker arm itself is spring loaded for the purpose of keeping the lever in contact with the cam and preventing noise. There is a drain plug fitted to the sediment chamber.

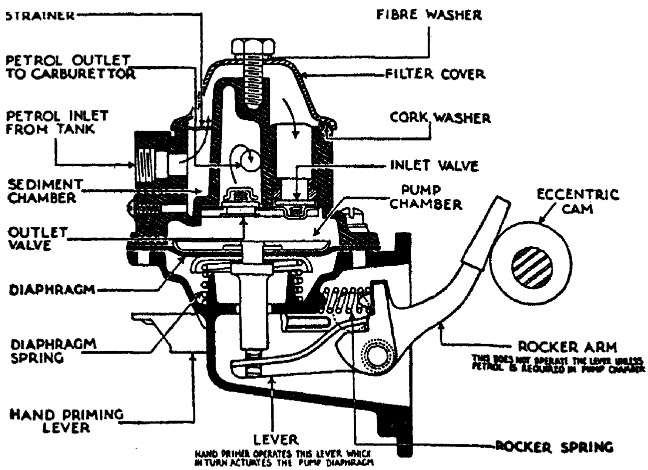


Fig. 261.—The A.C. Fuel Pump.

Running Adjustments.—A hand primer is fitted to the pump so that it is unnecessary to turn the engine either by hand or by the starter if the tank has run dry and the pump become empty. A few strokes on the hand primer will soon fill the carburettor-float chamber.

If the pump fails to supply petrol to the carburettor, attend to the following points:

Remove the filter cover and clean the gauze.

Make certain that the cork washer lies flat on its seat and makes an air-tight joint, and that the fibre washer is under the head of the cover screw.

Examine the pipes and connections for possible leakage. If petrol leaks at the diaphragm, tighten the screws alternately to ensure a good joint. If petrol does not flow from the pump to the carburettor, examine the small filter fitted inside the petrol-pipe union to the float chamber.

The Amal Fuel Pump.—This pump belongs to the cam-operated, flexible diaphragm class. Referring to Fig. 262, the camshaft (A) has an eccentric (B) which operates a rocker arm (C), pivoted at the point (D).

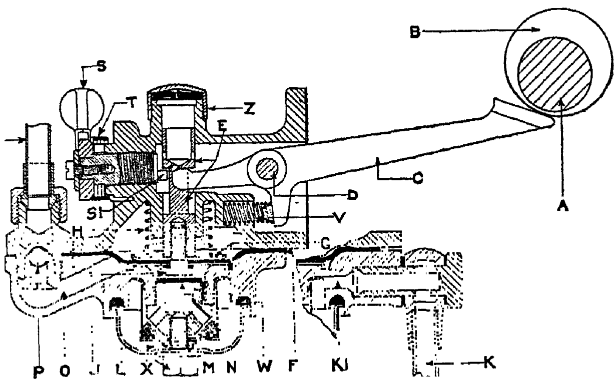


Fig. 262.—The Amal Fuel Pump.

When the shaft (A) revolves, the rocker arm (C) lifts the spindle (E) to which is fixed the diaphragm (F), which is interposed between two metal discs (G), so inducing petrol to flow from the tank up the pipe (K) through passage (K1) into the filter sump (L) through the filter (M) and the suction-disc valve (N) into the pump chamber (J).

The shaft (A) continues to revolve, and the diaphragm (F) commences its downward stroke solely under the influence of the spring (H), the suction valve (N) closes, and the fuel is forced along the passage (O), past the delivery valve (P), and up the pipe (R) to the carburettor.

When the carburettor float chamber is filled, the float will shut off the inlet-needle valve, thus creating a pressure in the pump chamber (J) which will react

against the diaphragm (F) and also the spring pressure (H), causing this to remain in the "raised" position.

The lever (C), under these conditions, can no longer give the spindle (E) any movement, due to the fact that it is raised beyond the point where the lever (C) engages the spindle (E). The lever (C) then simply moves backwards and forwards idly, and the pump can no longer deliver any fuel until the needle valve opens in the carburettor float chamber to admit a further supply. The pressure in the pump chamber (J) then falls and allows the spindle (E) to drop and once more come in contact with the lever (C).

The spring (H) is set at a pre-determined pressure, and this cannot be exceeded under any circumstances of the pump's operation.

The spring (V) is merely for the purpose of maintaining the rocker arm (C) in contact with the eccentric (B) to prevent noise.

The filter sump (L) is removed for cleaning purposes by unscrewing the hexagon nut (X); the filter (M) can then be unscrewed, cleaned, and replaced. The sump (L) is afterwards fitted and screwed up tightly so as to make an air-tight joint by means of the cork washer (W).

The priming lever (S) is operated by hand. This brings the cam of the priming lever (S1) in contact with the spindle (E), so working the diaphragm; about a dozen slow strokes is all that should be necessary for petrol to reach the float chamber of the carburettor. When this occurs, and the float chamber is full, the resistance to movement of the priming lever (S) will gradually diminish, until it is felt that it ceases to act.

The engine can then be started up, and the pump will continue to function in the normal manner. The priming lever (S) is held back, when not in use, by the return spring (T). The inspection cover (Z) can be screwed off for examination of the working of the pump spindle.

The Tecalemit Fuel Pump.—This type is suitable for use with petrol, benzol or fuel oil and has a low working pressure giving a steady delivery of 0 to 18 gallons per hour according to requirements. It employs light stainless steel disc valves and has an air dome which smooths out diaphragm pulsations, prevents flooding of the carburettor and acts as a storage reservoir which aids starting.

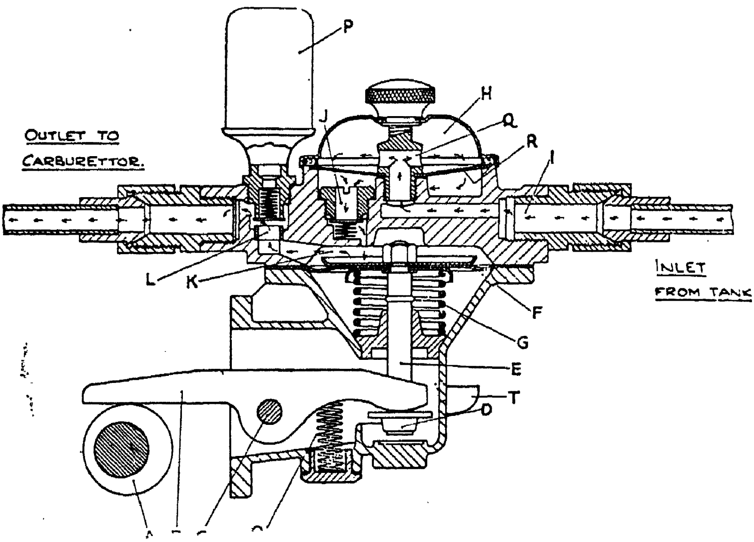


Fig. 263.—The Tecalemit Fuel Pump.

The engine eccentric A running at one-half engine speed causes the lever B to oscillate about pivot C and depress collar D on spindle E and pull the diaphragm F downward against the action of spring G. This produces a vacuum on the upper face of the diaphragm causing fuel to enter chamber H by means of union I and passage Q from where it passes down through the filter gauze R and inlet valve J to chamber K.

As the eccentric rotates, the lever B will tilt assisted by spring O allowing the collar D, spindle E and diaphragm F to rise by virtue of spring G so as to pump the fuel in chamber K past the outlet valve L to the carburettor or injector pump, as the case may be.

Should the engine demand the full quantity of fuel

the diaphragm follows the full stroke but when (in the case of a carburettor) the float chamber needle valve closes, a back pressure develops at the working face of the diaphragm causing a lag in action between the collar D and the working face of the lever B.

A certain level of fuel will be maintained in air dome P while running and the cushion of air trapped in the dome will permit a small quantity of fuel to flow to the float chamber when the engine is at rest to make up for evaporation losses in the float chamber, thus assisting in an easy start.

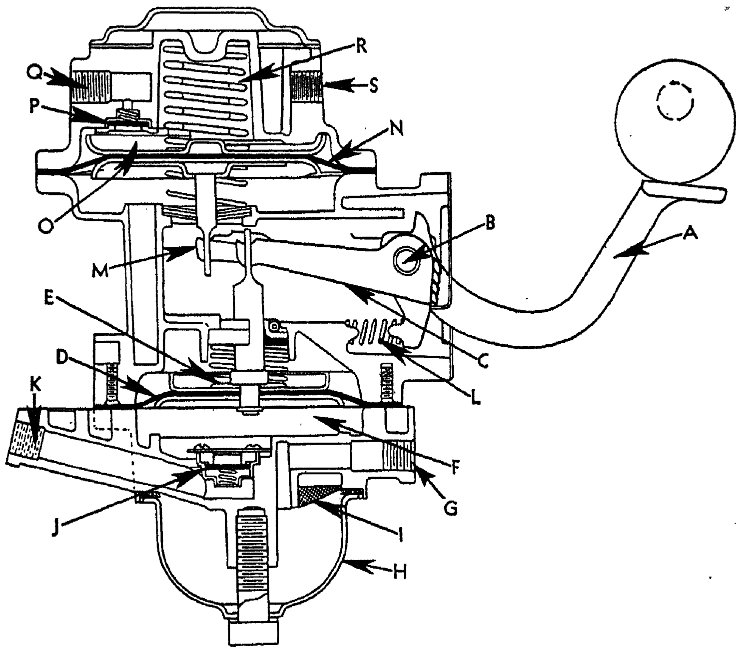


Fig. 264.—Combined Fuel and Vacuum Pump.

A Combined Fuel and Vacuum Pump.—A number of American cars are fitted with a combination fuel and vacuum pump, the latter ensuring a constant vacuum for the wind-screen wiper, irrespective of the inlet manifold vacuum. The advantage of this arrangement is that the windscreen wiper does not cease working at low car speeds.

The fuel pump portion follows standard practice. In regard to the vacuum portion the rotation of the camshaft eccentric actuates the rocker arm (A) pivoted at (B) which pushes the link (M) and in turn the diaphragm (N) upward, expelling the air in the chamber (O) through the exhaust valve (P) and out of the opening (Q) to the intake manifold.

On the return stroke of the rocker arm (A), the spring (R) moves the diaphragm (N) downward, creating a suction in the chamber (O) opening the intake valve, and drawing air through the inlet passage (S) from the windshield wiper.

When the windshield wiper is not being used, the manifold vacuum holds the diaphragm (N) upward against spring pressure (R) so that the diaphragm does not make a complete stroke for every stroke of the rocker arm (A).

When the manifold vacuum is greater than the vacuum created by the pump, the air will flow from the windshield wiper through both valves of the pump, and the operation of the wiper will be the same as if the pump were not installed.

However, when the intake manifold vacuum is low—that is, when the car is accelerating or operating at high speed—the vacuum created by the pump will be the greater and will operate the wiper.

The Ford Fuel Pumps.—The majority of Ford cars in present service employ cam-operated pumps of the diaphragm type as shown in Figs. 265 and 266.

In each case the main fuel tank is at the rear of the car, the level of the petrol being indicated by a gauge on the instrument panel; it is of the electric type, operated by means of a float actuating a lever which is geared to operate a variable resistance in the circuit of the indicator gauge.

The fuel pump is located on the near-side of the engine, towards the front, and is driven by an eccentric on the camshaft (see Fig. 265). It draws the petrol from the tank and supplies it to the carburettor. Being automatic in action, the pump requires little attention other than to keep it free from dirt, and all connections tight.

The construction of the pump is such as to provide a trap for sediment or water, which can be drained off by means of the drain plug on the side of the pump, after loosening the inlet-pipe union (immediately above the drain plug).

If it is desired to clean the pump screen, it may easily be reached by undoing the screw in the centre of the pump cover and removing the cover. When replacing the latter, the cover gasket should be examined to ensure that it is not broken.

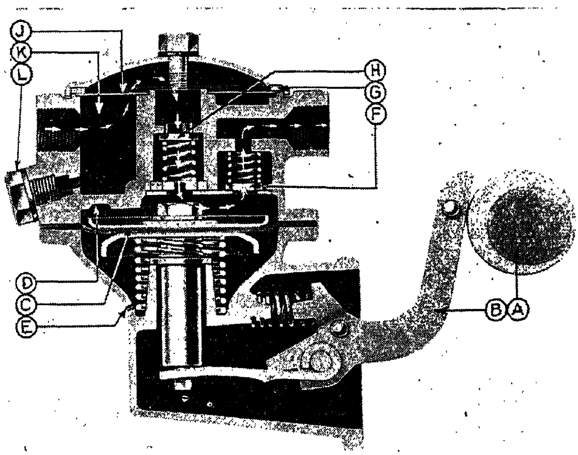


Fig. 265.—The Ford 8 and 10 H.P. Model Fuel Pump. *A*—Cam; *B*—Operating Lever; *C*—Diaphragm; *E*—Drain Hole; *F*—Outlet Valve to Carburettor; *G*—Cover; *H*—Inlet Valve; *J*—Washer; *K*—Fuel Inlet Chamber; *L*—Sediment Drain Plug.

Tracing Troubles with Ford Pumps.—If at any time the carburettor is not receiving sufficient petrol, one of the following is the possible cause:—

(1) Fuel tank empty.

(2) Screen in the top chamber of the fuel pump has become fouled with sediment, in which case it should be cleaned.

(3) The petrol pipe or its connections have a leak at some point, permitting the entrance of air to the pipe, or the drain plug on the pump is not screwed

home properly. The remedy, of course, is to stop the leak, at which time the pump will prime itself and again function properly. Cranking the engine for twenty seconds with the starter should prime the pump.

(4) If at any time petrol is seeping through the small hole (E), shown in the lower half of fuel pump (see Fig. 265), it is probably an indication of the diaphragm in the pump having become punctured. While this does not usually render the pump inoperative immediately, it is advisable to replace the diaphragm as soon as possible.

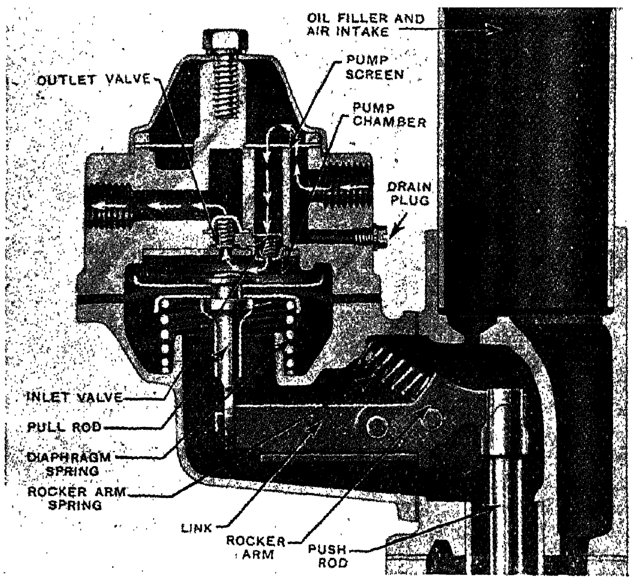


Fig. 266.—Ford Vee-Eight Fuel Pump.

The Ford V-eight fuel pump is shown in Fig. 266. It is located at the top of the engine behind the carburettor, and is driven by a push rod actuated by an eccentric on the camshaft. It draws the petrol from the tank and supplies it to the carburettor. Being automatic in action, the pump requires little attention other than to keep it free from dirt and all connections tight.

The construction of the pump is such as to provide a trap for sediment or water, which can be drained off by means of the drain plug on the side of the pump, after loosening the inlet pipe union (immediately above the drain plug).

The design of the pump is similar to that of the Ford 8 h.p. model, and the maintenance instructions are the same as for the latter model.

The later model 22 h.p. V-eight, as well as the 15 cwt. van and 25 cwt. Ford commercial vehicles, employ electric petrol pumps.

The R. and S. Petrol Pump.—A particularly neat form of petrol pump of the plunger-diaphragm type, with internal eccentric cam operation and visible glass container-type filter, is that known as the "R. and S." type, and made by Messrs. Rotherham, of Coventry. This has an eccentric throw of only ·05 in., and has an output of 10 gallons per hour at 2,000 r.p.m., with a maximum pressure of 2 lbs. per sq. in. It is capable of raising petrol without priming, a distance of 3 ft. at 20 r.p.m.

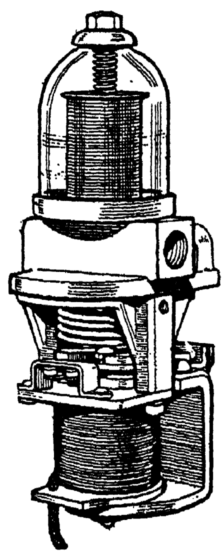


Fig. 267.—The Autopulse Petrol Pump.

The Autopulse Pump.—The Autopulse (Fig. 266) is another well-known electrical petrol pump, of American origin. This has a visible filter chamber built into the pump and placed above the electrical unit. It is noiseless in operation, and has duplicated contacts to increase the life and reliability. It has also an external adjusting screw to vary the capacity of the pump.

CHAPTER XV

INLET MANIFOLD DESIGN

Inlet Manifold Design.—The design of the inlet manifold is of much importance, since a badly designed one will account for bad mixture distribution, vaporization and running. In this connection the bore of the manifold should be the same as that of the inlet valve port, and the bends in the former should be as gradual as possible. Sharp bends, or sudden changes in section or curvature of the inlet manifold bore, cause not only a loss of maximum charge to the engine, but also a deposition of liquid

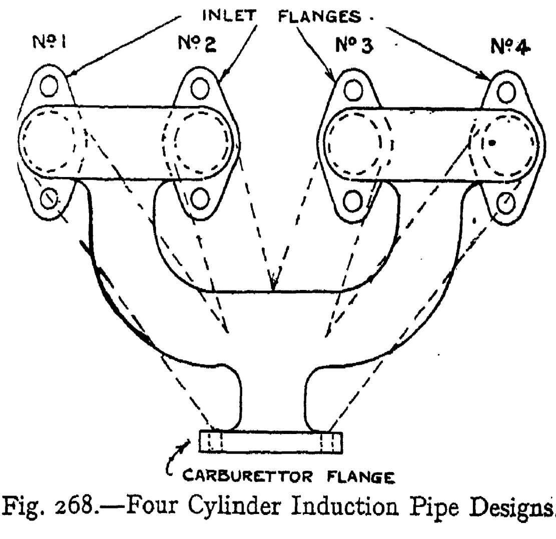


Fig. 268.—Four Cylinder Induction Pipe Designs.

particles of fuel at these places, with consequent bad vaporization and uneven mixture distribution to the cylinders. In the case of multi-cylinder engines the distribution of the mixture to the various cylinders is an important matter. When the mixture is moving at high velocity in the inlet manifold the fuel droplets exhibit an inertia effect which tends to make them

overshoot certain branches to the cylinders so that some of the latter may be starved, whilst others receive over-rich mixture.

By careful attention to the inlet manifold design these effects can, to a large extent, be avoided.

We have referred to the "hot-spot" method of vaporizing any such deposited liquid; it is better, however, to avoid the deposition. The internal diameter of the vertical branch of an inlet manifold can taper, with advantage, from a few millimetres smaller than the outlet of carburettor to the same size as the branch at the carburettor flange.

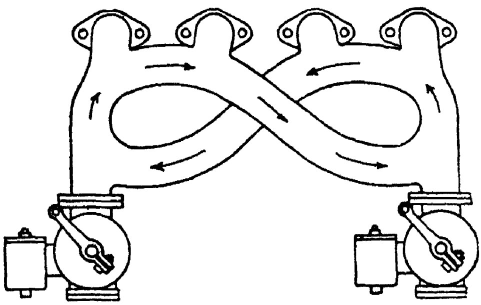


Fig. 269.—Racing Engine type of Uniflow Induction Pipe.

The four branch type induction pipe shown in Fig. 268 is commonly used, although a better arrangement would be that shown by the dotted lines; the mixture in this case would have a straighter path, and there would be no interference between the mixture flows of the respective cylinders. In this connection experiments have shown that if in the example shown in Fig. 268 a central baffle be fitted, so that each pair of cylinders can only draw mixture direct from the carburettor (i.e., each pair fed by a common branch is isolated from the other pair by the baffle an appreciable increase in power output is obtained.

It was at one time considered that if the lengths of the pipes or passages to the different inlet valves of the engine were different an uneven distribution occurred; this is hardly the case, however, but it is *the presence of bends* which cause charge losses.

Shape of Inlet Manifold Bends.—Reference has already been made to the necessity of avoiding sharp bends, when maximum charge or volumetric efficiency is to be attained. The reason for this is that when the mixture flows around a bend there is little loss of charge efficiency other than the unavoidable loss due to surface friction, since there are no eddy regions as in the example of the sharp bend shown in Fig. 270A,

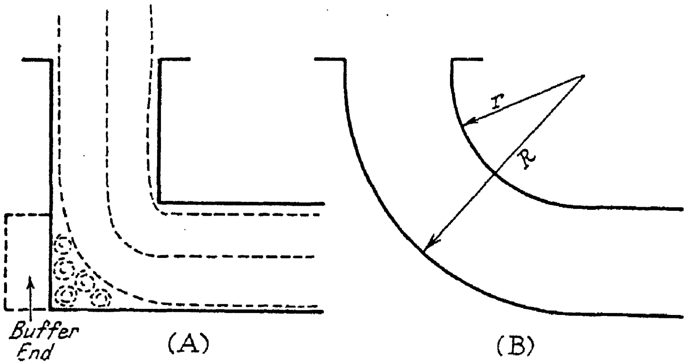


Fig. 270.—Illustrating Shape of Induction Pipe Bends.

in which the section of the mixture stream is actually reduced by the presence of the angle.

When the curved shape, shown at B, is employed the mean radius $\frac{R+r}{2}$ should be as great as possible under the circumstances. The reason for this is that the mixture, which in modern petrol engines, travels with a mean velocity of 180 to 240 feet per second, in traversing the curve experiences a centrifugal effect which tends to throw the solid particles of the mixture outwards against the inside of the pipe, namely, of radius R in Fig. 270B. This centrifugal effect varies inversely as the radius of the bend, so that the smaller the radius the greater will be the tendency to deposit fuel on the outer part of the bend.

In some instances the square-ended pipe shown at A (Fig 270) is favoured as when the valve port is close to the inlet pipe; in this case the end of the latter is extended— as shown by the dotted lines at A—in order

to form a "buffer" chamber to help damp out pulsations in the inlet manifold; these pulsations are due to the sudden closing of the inlet valve and, in consequence, the stopping of the mixture flow in this direction. In such cases the cross-section of the inlet manifold is made fairly large in order to obtain the greatest volumetric efficiency possible.

Four-Cylinder Manifolds.—The arrangement shown in Fig. 268 refers to the earlier vertical type carburettor in which the air, before reaching the inlet manifold hori-

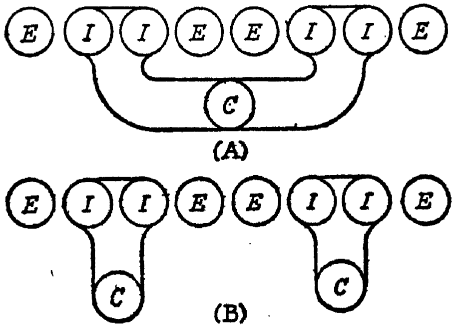


Fig. 271.—Four-cylinder Engine Inlet Manifolds.
C—Carburettor. E—Exhaust Ports. I—Inlet Ports.

zontal portion has to make two 90° changes of direction; if the main air intake is vertically below the choke tube, then only one 90° turn is made—as with the down-draught and straight-through types of carburettor. There is therefore a greater loss of charge efficiency with the former pattern carburettor.

In order to improve the charge efficiency the inlet valves of the two end pairs of cylinders are placed together, as shown in Fig. 271(A); thus simplifies the inlet manifold design and reduces the number of changes of path for the mixture.

When twin carburettors are fitted, these may conveniently be arranged as shown in Fig. 271(B).

Six-Cylinder Manifolds.—There are several alternative arrangements possible for the manifolds of six-cylinder engines. Two typical examples giving good volumetric efficiency are shown in Fig. 272. In the

example shown in the lower illustration there is a greater difference between the lengths of the mixture

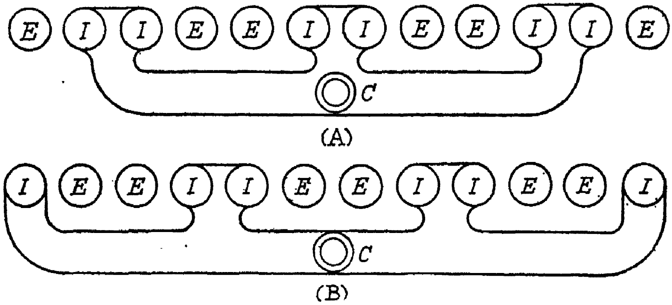


Fig. 272.—Six-cylinder Engine Inlet Manifolds.
C—Carburettor. E—Exhaust Ports. I—Inlet Ports.

paths than in the case of the one illustrated above. It is therefore to be anticipated that the quantities of mixture received by the individual cylinders in the latter example will be more uniform than in the former case, in which the end cylinders will tend to receive rather less than the two inner cylinders.

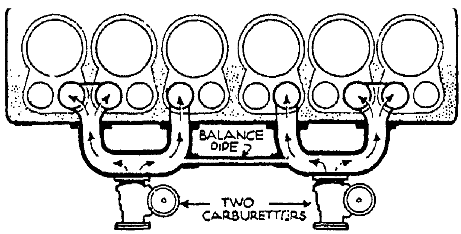


Fig. 273.—Improved Six-cylinder Engine Inlet Manifold using Two Carburettors.

When two carburettors are employed a good arrangement is that depicted in Fig. 273.* The mixture flow paths are practically the same for each of the six cylinders. It will be noted that there is a small bore pipe connecting the pairs of inlet manifolds to balance the pressures and thus to ensure more equal mixture distribution.

Straight Eight Manifolds.—In the straight eight-engine fitted with a single carburettor, owing to the necessity of the latter being placed centrally in rela-

* The Autocar.

tion to the cylinder block, the inlet manifolds are necessarily longer and more complex than for the other examples previously mentioned. The use of longer manifolds results in some reduction of charge efficiency owing to the increased frictional effects experienced by the high velocity mixture; there is also a greater tendency to precipitate fuel on the walls of the manifold. The design giving the most satisfactory results is that

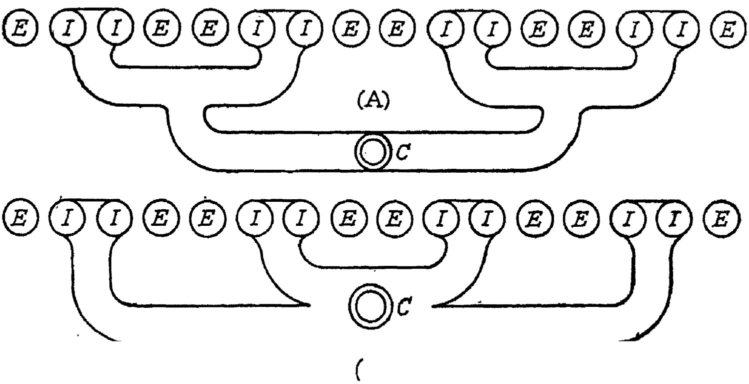


Fig. 274.—Alternative Eight-cylinder Engine Inlet Manifolds.

in which the mean lengths of the branches, or mixture flow paths are nearly the same. It is difficult, however, to obtain good mixture quality and equal quantity in all of the cylinders, but some improvement is obtainable by careful design of the inlet manifold heating arrangement. It is better, however, to treat the engine as two four-cylinder ones placed end to end and to provide a separate carburettor to each set of four cylinders, thus duplicating the arrangement shown in Fig. 271.

Throttle Position and Distribution.—An important matter in regard to mixture distribution concerns the design and arrangement of the carburettor throttle. In the case of cylinder pattern throttles the mixture tends to have a bias towards one side of the inlet manifold and therefore to give a greater quantity of mixture to the branch pipe on that side (Fig. 275). Similarly, with the butterfly-type throttle there will be a bias towards one side, and therefore one branch of the inlet manifold.

If, however, the throttles, in each case, are set with their axes of rotation parallel to the axis of the inlet

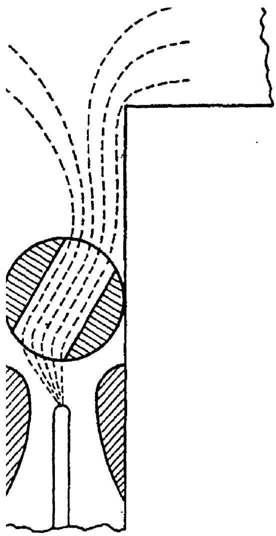
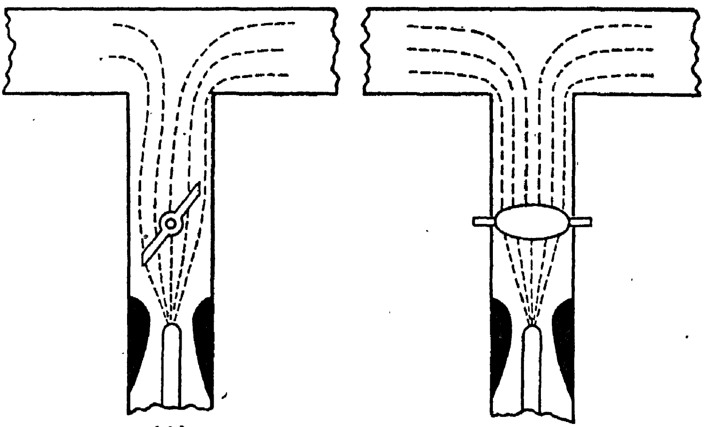


Fig. 275.

manifold branch the mixture will be distributed evenly between the two branches of the manifold.



(A) (B)

Fig. 276.—Butterfly Throttle Alternative Positions. The arrangement shown at (B) gives better distribution than that of (A).

Supercharged Engines.—The difficulties in connection with the distribution of the mixture to the

various cylinders, and to fuel deposition in the inlet manifold, common to normal petrol engines, do not occur to the same extent with supercharged ones.

The "raw" mixture from the carburettor is, in the latter instance, led straight to the rapidly rotating blower, where it becomes violently agitated, and at the same time heated by the compression heat effect of the supercharger. Apart from the tendency to vaporize the fuel, there is a better mixture distribution to the cylinders, of the homogeneous fuel-air mixture, more especially when the supercharger is between the engine and carburettor.

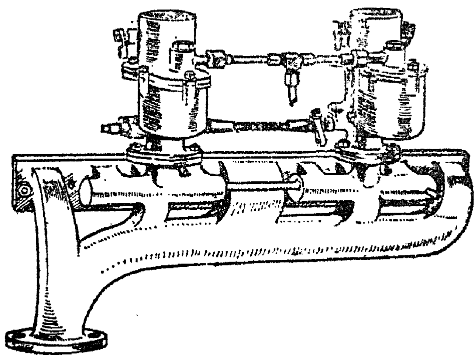


Fig. 277.—Twin Carburettors of the Vertical Down Draught Type

It is often found that even with a small blower, so small that the supercharge pressure is very little above atmospheric, the performance of an engine at low speeds is greatly improved owing to the better mixture distribution and more uniform quality mentioned.

In certain types of racing car engines, attempts are made to increase the quantity of charge drawn into the cylinders by using special designs of inlet manifold, such as the one shown in Fig. 269, the design illustrated gives a uni-directional flow. In this respect it should be remembered that there is always a surging action of the mixture in the inlet manifold due to its inertia and to the sudden opening and closing of the inlet valves, and that the surgings of the respective valves are apt to interfere with the general mixture flow. If the inlet pipes and passages can be kept separate, therefore, so much the better.

The same applies also to the exhaust manifolds; separate manifolds are in general more efficient than a combined one.

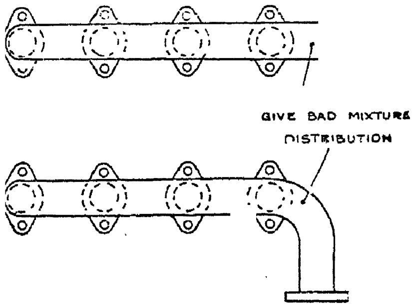


Fig. 278.—*A* and *B*—Inefficient Designs of Induction Pipe.

Multiple Carburettors.—As distinct from the dual type of carburettor, which has its own design of inlet manifolds leading from the carburettor unit, there is the multiple carburettor system, in which each cylinder, pair of cylinders or group of three adjacent cylinders each has its own separate carburettor. Thus a four-cylinder high-speed engine may have two

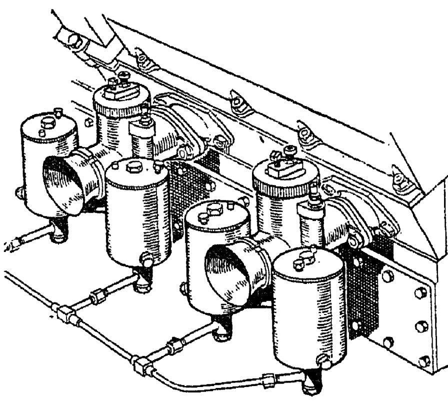


Fig. 279.—Multiple Carburettors with Twin Float Chambers (Autocar).

carburettors; a six-cylinder engine, three, and so on; many racing and high efficiency engines employ this system. With this arrangement, the inlet manifold

system is not only simplified, but it is made very much shorter and more free from bends. It will be evident that with suitable designs of carburettors a higher volumetric efficiency is possible and a better control of mixture strength is provided.

The disadvantages of the multiple carburettor method are that they are more costly, more complicated—owing to duplication of petrol piping, throttle and choke controls, and usually they are more difficult to "tune up" or to maintain in tune.

Fig. 279 illustrates the Fraser Nash multiple carburettors, in which each pair of cylinders has its own separate carburettor; moreover, each carburettor has twin float chambers to prevent mixture variations due to tilting or surging effects.

Tuning Multiple Carburettors.—The usual method is to fit the same size of carburettor as would be employed if a single one were used for the complete engine; it is incorrect to assume that smaller chokes and jets are possible with separate carburettors.

The size of carburettor, whether for a single or multiple cylinder engine is, with certain limitations, dependent only upon the stroke, bore and maximum engine speed. There are, however, certain differences between dual and triple carburettor fitting and tuning. The following notes on this subject refer primarily to Solex carburettors. In the case of dual carburettors, the setting as a rule is more or less identical with that of a single carburettor, and it is only a question of synchronising the two. This is best effected by having an adjustable link in the connecting-rod between the two carburettors, and the synchronisation is best effected by getting them adjusted down to the lowest possible "idle". If then provision is made to "short" first the front three cylinders, and immediately afterwards, the back three, it is easy to note by the difference in the respective idling rates whether the throttle positions are identical, and when corrected so that both halves idle at the same speed, one can be assured of synchronisation throughout the upper parts of the range, and tuning thereafter is provided by ordinary step by step trial and error choke and jet changes.

That is to say, with a specific choke size up and down main jet changes are made, and increasing or decreasing as the case may be is progressively carried to the optimum with that particular choke, after which a variation in the choke size again up or down to commence with is tried, and with this, the jet optimum is once more established.

By this means it is easy to see whether bigger or smaller chokes are needed, and having established the direction in which to work, it becomes quite a simple trial and error progression until the desired results are obtained; the carburettors, of course, being adjusted identically in this case.

When dealing with three carburettors, however, the conditions are different, because such a fitment is generally applied to a three-port engine, and it so happens that the aspiratory progressions on carburettors 1 and 3 have a long and a short period, but the middle has equal intervals. The result of this is that although the choke size as a rule may be identical, the extreme carburettors require one or two main jet sizes bigger than the middle one, owing to the disturbances created in the inertia of the petrol columns in the main jet assemblies by irregular intervals of inspiration.

The question of adjusting for slow-running in the case of a six-cylinder engine with more than one carburettor is always simplified greatly by considering the engine in two halves, because one can then hear irregularities much more easily than when all six cylinders are operating, and the best general plan, whether with two or three carburettors, is always to "short" the two halves and adjust them individually by means of a stop-watch to the same minimum idling speed

CHAPTER XVI

MISCELLANEOUS FITTINGS

Extra Air Fitments.—It has been mentioned that it is practically impossible to design a commercial carburettor so that it will automatically give the same mixture strength at all speeds and at all throttle openings and loads. Most instruments represent a creditable compromise in this respect, and it follows that if an additional auxiliary air supply is provided and is operated on appropriate occasions, a better fuel economy will result, and the performance of the carburettor may be improved. The principal advantages of the auxiliary air supply device are: (1) That it enables the driver to dilute the rich mixtures which many carburettors give at the higher speeds, and (2) that by switching off the engine, and opening fully the auxiliary air supply, the engine can be made to act as a brake on long declivities; moreover, the air drawn in cools the engine. Many modern carburettors, however, are now fitted with dashboard controls for weakening or enrichment of the mixture as required, so that the extra air valve is not needed to the same extent.

The early types of extra air valve consisted of a plunger sliding in a tube. screwed direct into the inlet pipe, the plunger being operated in one direction by a Bowden cable, and returned by a spring. The tube had a series of holes in its sides, which were uncovered by the plunger and thus admitted air directly to the engine. Other forms consisted of automatic air inlet valves, the tension of the spring control of which could be varied by means of a screw adjustment; this type, depending as it does on engine suction (and speed) alone does not give satisfac-

tory results under all conditions. The type of extra-air valve which has been popular is illustrated in Fig. 280. The Bowden device shown consists of an inner hollow spring controlled piston which can slide in a cylinder, provided with air ports, and is operated by a Bowden cable from the driver's seat. An outer annular chamber is also supplied to slip over the ordinary air valve and contains a piece of wick held both inside and outside by wire gauze. The wick can be saturated with petrol prior to starting, and the air drawn in through the top ports passes over the surface of the wick and will be sufficiently carburetted to start the engine. The device therefore combines both an extra-air valve and an easy starter.

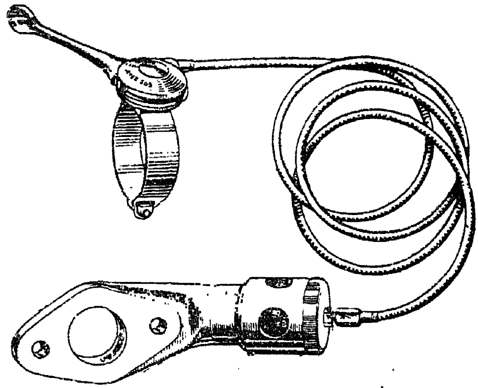


Fig. 280. The Bowden Auxiliary Air Fitment (Inlet Pipe Flange Type).

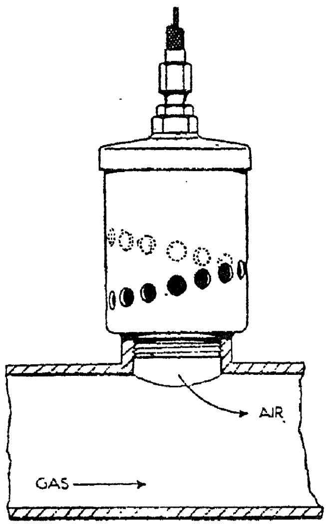


Fig. 281.—Bowden Extra Air Control for Coal and Producer Gas Automobile Engines.

The most convenient position for fitting an extra-air valve is usually between the flanges of the carburettor and inlet manifold; several types of auxiliary air device take the form of a dummy flange of the same shape as those mentioned bolted between these. The extra air required is arranged to enter through this flange

to the inlet pipe. Another type supplied bolts directly to the inlet pipe, a hole being drilled for the air supply.

Fig. 281 shows a more recent type of Bowden extra air device which is intended, primarily, for regulating the admission of air to coal or producer gas operated automobile engines. It is provided with a series of holes arranged in spiral manner in an outer casing, which are uncovered progressively by an internal piston moved upwards by Bowden cable control; a compression spring return is provided.

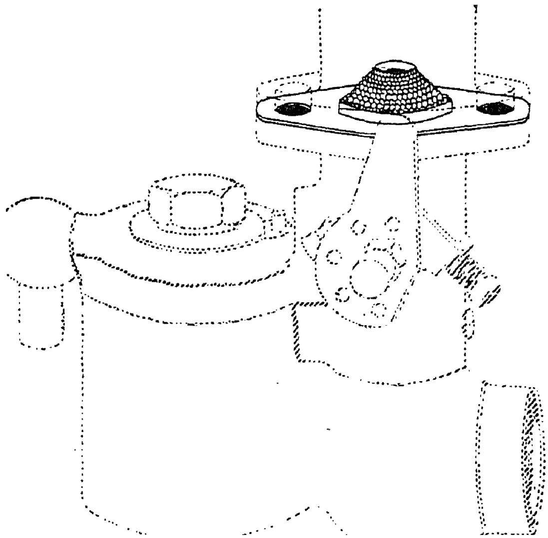


Fig. 282.—The Vokes Mixture Distribution Rectifier.

Carburettor Vaporizer Attachment.—A device for improving the atomization of the fuel, known as the Vokes Distribution Rectifier is illustrated in Fig. 282. It consists of a series of small mesh apertures arranged in conical formation on a plate which is fitted between the flanges of the carburettor and inlet manifold. The apertures break up any larger particles of fuel and at the same time give a straightening effect to the mixture stream and results in a better admixture of the air and fuel. It is claimed to effect better distribution to the cylinders of multi-cylinder engines, but the matter of even distribution must be primarily governed by the

inlet manifold design. The device should improve the mixing of the fuel and air in certain designs of carburettor not provided with the usual atomizing type of main jet, but in view of the fact that the mean speed of the mixture through the inlet manifold is of the order of 200 feet per second, under full throttle conditions, the resistance offered by the device may be expected to reduce the charge efficiency at full throttle.

Carburettor "Tickler."—Some patterns of carburettors will enable their engines to start up more readily from the cold if they are "flooded". The usual procedure is to depress the plunger, provided for this purpose, on the top of the float chamber. A better way, which does not necessitate opening the bonnet of the car, is the Bowden operated float depressor, illustrated in Fig. 283. This consists of a plunger, normally held clear of the float needle mechanism by a Bowden cable, on releasing which a spring forces it down so as to depress the float lever, and raise the needle valve. This operation can, of course, be carried out from the driver's seat, and in cases where the engine speed drops, when working on full throttle, due to weakening of the mixture, the latter can be enriched temporarily by using the above device.

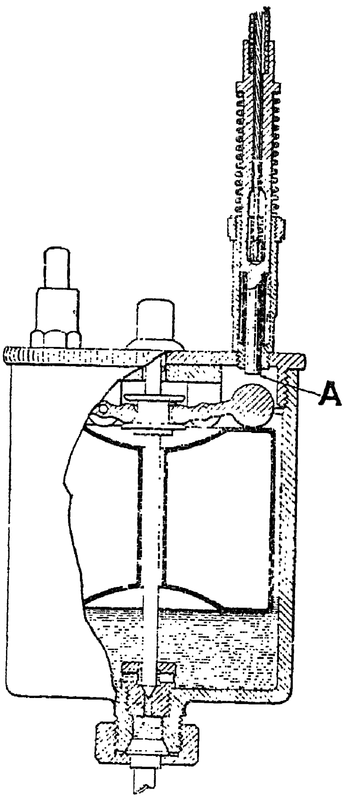


Fig. 283.—The Bowden Carburettor Flooding Device (Dash Operated).

Humidifiers.—There is another class of apparatus auxiliary to, or combined with, the usual carburettor.

in which water or steam is supplied with the fuel air mixture to the cylinder, and for which certain beneficial claims are made. It is well known that some engines appear to pull better in damp or foggy weather, or on misty nights, and it is believed that the atmospheric moisture improves the running of the engine. Certain official tests made by the American Bureau of Standards on water-injection failed to discover any advantages except a reduced carbon deposit in the cylinders. It is possible that the improved running is partially due to a lower charge temperature, and

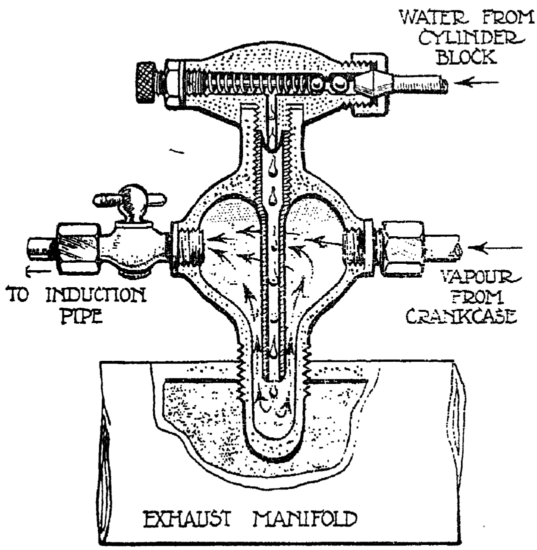


Fig. 284.—The Lovelace Volatizer.

therefore a greater quantity of mixture drawn into the cylinder. On the other hand the increased quantity of moisture in the air drawn in will, owing to its latent heat and to dissociation, tend to keep the explosion and mean temperatures down, and enable a better running, in some cases, to be obtained; more particularly with those engines which normally run on the hot side; in other words, additional internal cooling occurs. There has been a number of such devices known as humidifiers, produced and sold commercially, from time to time, which have had for their object the

introduction of moisture (and in some cases of oil) into the engine along with the fuel. In some cases steam from the radiator is employed.

Fig. 284 illustrates the Lovelace volatizer, which introduces water from the cylinder block and oil vapour from the crankcase into the induction pipe. The water is drawn through a non-return ball valve into the metal casting shown, and which is screwed into the exhaust pipe so as to vaporize the water and oil drawn from the crank-case. The cylinder mixture then consists of air, fuel, oil and water, and it is evident that the third item really acts as a fuel and is combusted in the ordinary way, the water serving as a temperature stabilizer. The results of an R.A.C. test of this device, fitted to a Ford light van engine, weighing 19 cwts., over a distance of 16·3 miles at Brooklands at an average speed of 20·3 m.p.h., gave a fuel consumption of 28·54 miles per gallon *without*, and 32·6 miles per gallon *with*, the device in action.

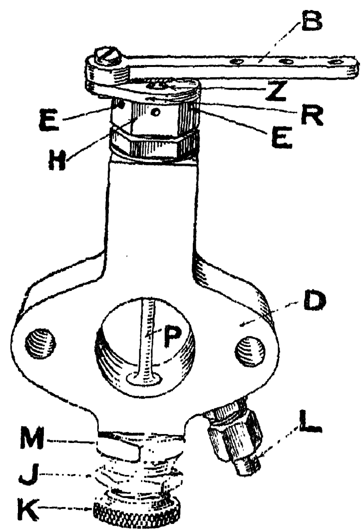


Fig. 285.—The Lotion Humidifier

Fig. 285 illustrates the "Lotion" humidifier, which takes the form of a flange fitting inserted between the carburettor and inlet pipe flanges, and is provided with a central hole corresponding to the inlet bore. Water is taken from the cooling system, or from a separate tank to the throttle of a double venturi H (no jet being used). At the top of the floating valve P is a small adjustable air port Z; for starting or slow running the floating valve P remains closed. The arm B controlling the air port is connected to the throttle so that on opening the throttle the air port is sealed, and the device in question becomes automatic; the air drawn by the engine from

the top of the floating valve causes the latter to lift and allows air and water to pass into the induction pipe in the form of a spray or mist, and passes into the engine with the mixture. The water inlet pipe connection is at L.

Electric Petrol Gauges.—The principal drawback of the usual tank-pattern petrol gauges is that they cannot be seen by the driver except when the car is stopped; moreover they are difficult to read by night.

It is now usual to fit the petrol gauge on the dashboard, where it can always be seen. Most of these gauges work on the hydrostatic or electrical principle.

Fig. 286 illustrates the principle of the electric petrol gauge fitted to the Vauxhall cars. It consists of two units—the dashboard indicator and the petrol tank fitting.

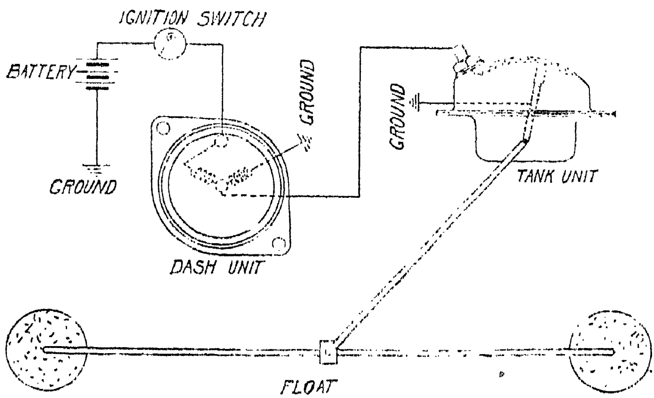


Fig. 286.—Showing Principle of Electric Petrol Level Gauge.

The indicator consists of two coils wound so that they have the same polarity in the faces exposed to the armature which is integral with the pointer. The dial of the indicator is graduated between "Empty" and "Full."

The tank unit encloses a resistance element with a moving arm which is actuated by a float arm immersed in the petrol tank. The outer terminal of the instrument panel is connected to the ignition switch so that the gauge operates only when the ignition is switched on.

When the tank is empty the floats are at their lowest position, and the resistance is cut out; this results in one of the coils in the dash unit being rendered ineffective, the other coil attracting the armature so as to cause the indicator to read "Empty."

As the petrol level in the tank rises, the resistance is gradually increased in the circuit of one coil, causing it to become weaker, and the resistance is gradually lessened in the other coil, by the same amount, so that it becomes more powerful and attracts the indicator towards "Full" on the gauge.

The current consumption of this gauge is very low, viz., about one-eighth ampère.

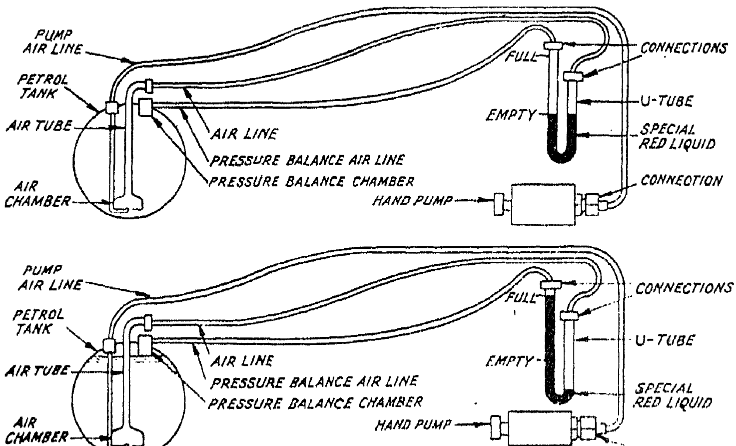


Fig. 287.—The Hobson K.-S. Telegage.
(Above)—Tank Empty Position. (Below)—Tank Full Position.

The Hobson K.-S. Telegage Petrol Gauge.—This type of fuel level indicator which has been used on numerous British cars consists of a dashboard indicating gauge having a vertical glass U tube containing a red liquid within, to indicate the fuel level, and a tank unit. The dashboard unit comprises the U-tube mentioned, one leg of which is connected to the top of the main tank, and the other to the bottom through a pair of small bore copper pipes. The tank fitting comprises a stand-pipe extending to within a short distance of the bottom of

the tank. A third pipe is taken from a small air pump situated under the dashboard indicator, to a point just below the mouth of the stand-pipe in the tank. All three pipe lines are enclosed for protection within a single flexible metallic tube, the unions provided on the pipes being of different sizes to ensure correct connections.

The indicator is operated by the hydraulic pressure-head due to the depth of fuel in the tank, and in order to ensure that this head shall be proportional to the total depth of fuel under all conditions, special provision is made to exclude fuel from the stand-pipe. Under running conditions this is effected by a series of cups mounted on the outside of the stand-pipe and connected by small pipes with the lower end of the latter. Rocking or surging of the fuel due to movement of the car uncovers one or other of these cups, which tends to empty itself through a hole and the small pipe referred to, and, in so doing, entraps bubbles of air. The latter are released into the stand-pipe, and displace any fuel which may have risen therein owing to absorption of air, condensation, etc. In another design of a similar type of fuel level gauge the hand pump is dispensed with so that the driver has no need to do anything in order to read the petrol gauge.

If the gauge fails to register correctly the cause may be due to damaged tank unit or leakage at one of the pipe line unions. Disconnection of the pipe lines may cause faulty reading of the gauge.

To correct this, the indicator pipes must be disconnected at both ends, *always disconnecting the rear ends first*, and a hand tyre pump *securely* connected to the front end. The air pump line need not be disconnected. About forty strokes of the pump as a minimum will serve to dry out the water or fuel, the pipes being reconnected immediately afterwards, coupling up the front ends first.

A rapid fall of the gauge reading when the car has been standing a short time indicates a leak in the pipe line between the gauge and the bottom of the tank.

The Hobson K.-S. Electric Type Telegage.—This later model Telegage operates upon the principle of using a resistance which can be varied to control the current flowing in a circuit proportional to the levels of the fuel in the supply tank using an ammeter type of dashboard indicator calibrated in fuel quantities The device in question comprises three parts, namely, the tank unit, or *Sender*, the instrument unit, or *Receiver*, and the single cable connecting them; the metal of the chassis forms an earth return.

The controlling element of both the *Sender* and the *Receiver* is a bi-metal strip.

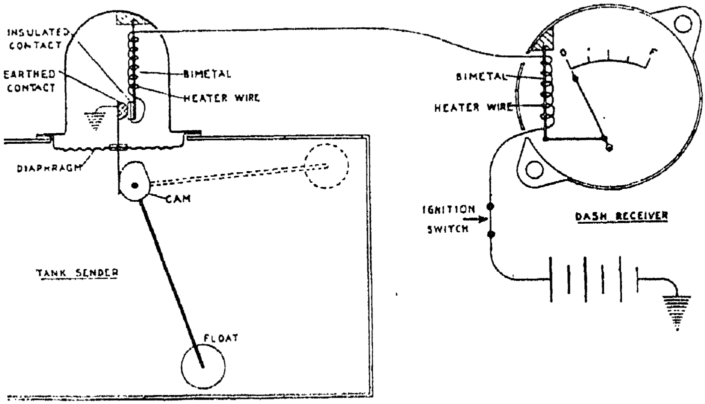


Fig. 288.—Hobson K.-S. Electric Telegage. (Tank Empty).

The bi-metal strips in both the *Sender* and *Receiver* are similar—that is, each will bend the same amount when heated to the same temperature. In order to heat both to the same temperature, each has an electrical heating unit wound around it. These heating units are connected in series and the current flows from the battery through the *Receiver*, then through the *Sender* to the earthed contact, and the circuit is completed through the car frame back to the battery. The same current which passes through the *Receiver* must also pass through the *Sender*, so that both bi-metals will be heated the same.

The bi-metal in the *Receiver* is anchored at the top, and the bottom is connected by a link to a pointer. Heating the bi-metal will cause it to bend to the right,

and this movement, amplified by the linkage, will be transmitted to the pointer, moving it to the right.

The bi-metal in the *Sender* is also anchored at the top, and carries a contact point at the bottom. When this bi-metal is heated, it moves to the right, away from the earthed point, and breaks the circuit.

Fig 288 shows the position of all parts of the fuel gauge system when the tank is empty. When the current is switched on, it will heat both bi-metals just sufficiently for the contact point of the *Sender* to move away from the earthed contact. The actual movement necessary to break the circuit in the *Sender* is so small that the movement of the pointer is not noticeable. As soon as the circuit is broken, the bi-metals begin to cool

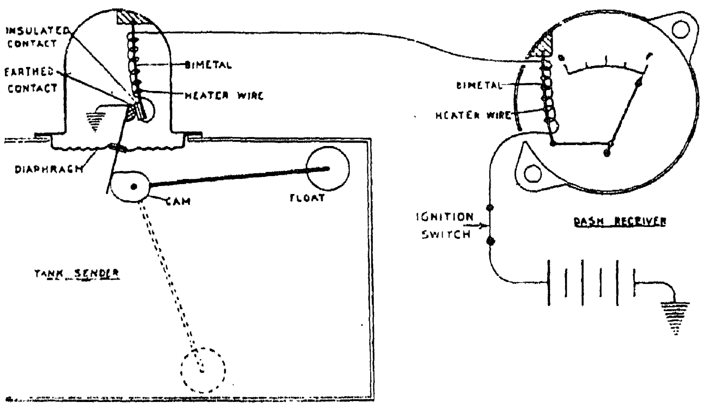


Fig. 289.—Hobson K.-S. Electric Telegage. (Tank Full).

and straighten so that the contact is again made. This process of making and breaking contact continues from 60 to 100 times a minute, the bi-metal being alternately heated and cooled, but to the eye, the pointer on the dial is steady.

Fig. 289 shows the position of the parts when the fuel tank is full. The float has moved upwards and, through the action of a cam, has pushed the bottom of the rod on which the point is mounted, to the left, and the point has moved to the right, this movement being made possible by mounting the rod on a flexible diaphragm. With the earthed point moved to the right, it will require more heat to bend the bi-metal

in the *Sender* enough to move the contact point away from the earthed point and break the circuit. The same current, however, that heats the *Sender* bi-metal is also heating the *Receiver* bi-metal and it likewise bends more, moving the pointer to the right. As soon as a sufficiently high temperature is reached, the points open and close alternately, maintaining this temperature and keeping the pointer steady at "full" on the dial.

Since this gauge depends entirely on temperature for its operation, a change in voltage in the system will not affect the gauge heading. A higher voltage will show a change in fuel level faster, but the final reading will be the same.

Since it takes approximately 15 seconds for the gauge pointer to change from "Empty" to "Full," bobbing of the float is not registered. The actual reading in case of a bobbing float is the average level of the float, which is the actual level of the fuel in the tank when at rest.

The only parts susceptible to deterioration in the entire system are the contact points. Since the maximum current flowing while the points are in contact is only three-tenths of an ampére, the life of the points is of little concern.

Petrol Filters.—It is now the rule to fit an efficient petrol cleaning device between the fuel supply tank and the carburettor, for any small particles of dirt, or globules of water will usually cause engine stoppage, or starvation of the fuel supply. Most petrol filters use a very fine-mesh brass gauze as the filtering element. This gauze must be of ample area to allow sufficient petrol to flow even if the gauze is blocked partially. One type of filter uses a large number of parallel brass plates separate by very small distances.

In the visible type of petrol filter shown in Fig. 260 the glass bowl surrounding the gauze filtering element enables any dirt or sediment to be seen at once. By unscrewing a milled nut below the glass and swinging the stirrup clear, the glass can be renewed for cleaning purposes.

It is desirable to clean out petrol filters every 2,000 miles or so, to ensure trouble free running.

In most visible type filters the petrol is arranged to flow into the space surrounding the cylindrical gauge element, whence it flows from the outside to the inside, through the gauge, upwards, and out from the top of the filter. In this way the particles of dirt adhering to the outside of the gauge can readily be cleaned off. In many modern carburettors the petrol filter is located in the petrol union member on the float chamber, where it is accessible for cleaning purposes.

CHAPTER XVII.

TESTING, TUNING AND TROUBLE TRACING

Carburettor Testing.—Assuming that the carburettor has been correctly fitted to the engine it is frequently desirable to know what mixture proportions it gives at different engine speeds, and also whether it enables the engine to develop its full power; accurate tests of a scientific nature are required in this case. On the other hand, only one motor user in a hundred has the means or qualifications to carry out such tests, and in any case only requires an approximate idea of the behaviour of his carburettor. There are several practical methods of testing carburettors which are available in such cases. Dealing, firstly, with the latter methods, the ordinary motor vehicle user requires to know whether his mixture is too weak or too rich when idling and when running normally; he may also wish to learn whether the carburettor he is using is giving the best power results under various conditions.

Tests for Weak Mixtures.—It is well known from experimental work on the subject that weak mixtures give the better fuel economies, but do not give the same power output as mixtures which are a little richer than the correct strength (viz., about 15 parts air to 1 part petrol, by weight).

There may therefore be a good mileage per gallon, but loss of power on hills, or a loss of acceleration and maximum speed with weak mixtures. To check for normally weak mixtures the car may be tested on a steep hill, noting the maximum speed attained at the start and the distance covered before the speed drops to a given value, say 10 or 15 m.p.h. Alternatively, the maximum speed attained on the hill, on top gear,

or on the level may be noted. The fuel jet should then be increased either by changing it for the next larger size, or, if a variable jet, by opening the needle valve a little, and the test repeated. The best mixture will be that which gives the greatest speed or distance up the hill as the case may be.

A weak mixture may also be detected by running the car at a given speed on the level, and when everything is steady, flooding the curburettor either with a makeshift device rigged up for the purpose, or by using a carburettor "tickler" such as the Bowden one previously described. Any increase of speed on flooding the carburettor will indicate that the initial mixture was too weak at the given speed. At low speeds the engine will pull erratically on top gear with a weak mixture; this can readily be tested, and the improvement in running noted when t richer mixture is given.

Very weak mixtures will often cause firing back or "popping" in the carburettor, due to their relatively low flame velocities; the mixture is then still exploding when the inlet valve opens again.

Weak mixtures tend to give *rather duller explosions*, and if the *exhaust flame* can be viewed it will be found to be rather *white* and less intense than that of the correct mixture flame, which is an intense light blue colour.

Weak mixtures will take appreciably more ignition advance and will give better running results at these —usually another 10° to 15° of crank angle ignition advance can be given in such cases.

Rich Mixtures.—As we have seen, mixtures a little richer than the correct one for combustion give more power but greater fuel consumptions, so that it is not difficult to test for these.

The fuel consumption test is probably the best, and there are a number of devices on the market, such as the Milegal, Gallometer and Hamill Flowmeter, which enable the fuel consumption to be measured during a

* If a variable jet, or "strangler," is fitted to the carburettor this should be used to enrich the mixture temporarily.

road test. Alternatively a small tank can be rigged up on the dashboard of the car (the main tank is usually too big for sufficiently accurate tests to be made), and filled to a given level with petrol. The engine should be thoroughly warmed up by running on the main tank. When properly warm, and the engine is running at a given speed (which should be the normal running speed) switch over the petrol supply to the auxiliary tank and run for a given distance, say a mile, on a level road, at constant speed, then switch over the petrol supply. The amount of petrol consumed can be measured either directly or by noting the exact quantity of fresh petrol which must be poured in to bring the fuel to the initial level; the car should be on level ground in this case.

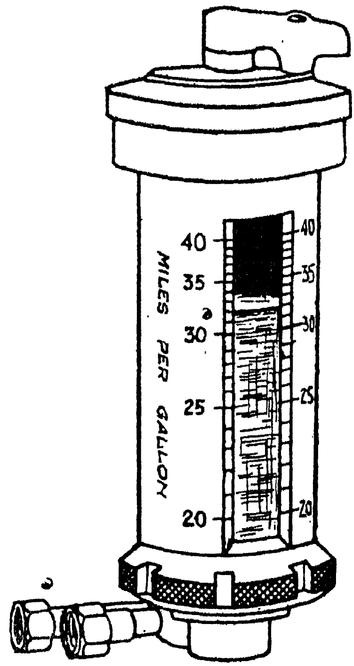


Fig. 290.—The Gallometer Automobile Fuel Consumption Device.

If n pints (or fractions of a pint) of petrol are used whilst the car covers a distance of d miles, the petrol consumption P (in miles per gallon) is given by:—

$$P = \frac{8d}{n} \text{ miles per gallon.}$$

Thus if $\frac{1}{4}$ pint of petrol is used in covering 1 mile the petrol consumption will be 32 miles per gallon.

Fig. 290 illustrates the Gallometer fuel consumption device. It consists of a glass cylinder, held in a graduated brass tube, provided with a slot through which the fuel level can be observed; the scale is graduated in "miles per gallon." There is a three-way filling device below. To make a test the glass vessel is first filled with fuel by turning the three-

way tap to the "filling" position, until a slight overflow indicates that it is full. When the car passes a milestone, or when the speedometer mileage figure reads an even number of miles, the tap is turned so as to cut off the main supply and to feed from the glass reservoir. As soon as a mile has been traversed, the tap is changed over to the main supply again, and the reading taken at the fuel level in the glass vessel. This reading gives, directly, the mileage per gallon

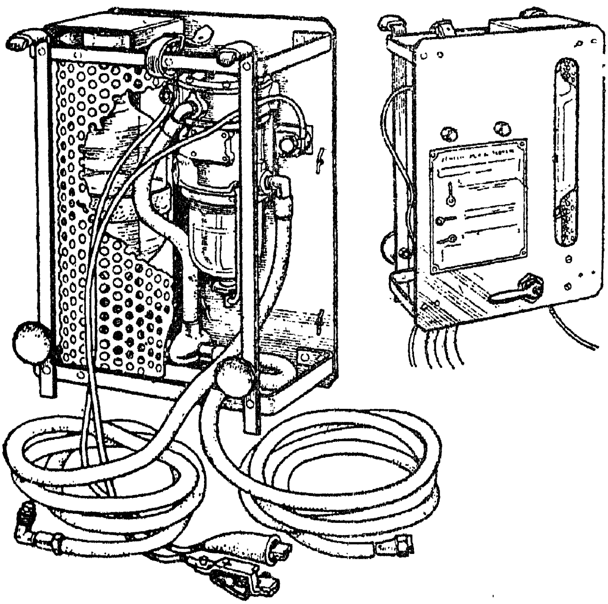


Fig. 291.—The Zenith Mileage Tester.

In the Milegal device, instead of a vertical glass vessel a cylindrical one is employed, the fuel level after running a mile being indicated (in miles per gallon on the scale) by a needle and concentric scale. The needle is connected by a pinion and quadrant mechanism to a pivoted hollow metal float, so that the former correctly indicates the fuel level.

The Zenith Mileage Tester.—A convenient commercial fuel consumption testing device is marketed by Messrs. Zenith Ltd. (Fig. 291.)

It comprises a metal frame in which are housed a

graduated fuel container, an electric pump for feeding the fuel to the carburettor and the necessary connections.

The device is fitted with a three-way tap, which in one position shuts off the direct fuel supply from the main tank and allows only the fuel from the testing container to go to the carburettor. The quantity of fuel used for a test is one-tenth of a gallon; as the testing container is made of glass the fuel can easily be seen. An advantage of the three-way tap is that by turning it to another position the main supply in the tank at once comes into operation; or, with the tap in yet another position fuel is fed to the testing container thus replenishing it, so that several tests can be made without stopping.

The testing device can be fixed to the dashboard, or on to one of the car windows (partly opened for this purpose). It is connected up with the carburettor and main fuel supply by means of rubber pipes. The pump supplied is an electric one operated from a six or twelve volt battery. The complete apparatus weighs 9 lbs.

Solex Consumption Tester.—The Solex petrol consumption tester, which acts also as an emergency petrol tank, consists of a small reservoir mounted on the back of the dashboard, under the bonnet, connected to the carburettor inlet, by means of a two-way fitting. The tank, which is made in two sizes, namely, one and two pints, has its own petrol tap. For gravity feed, this auxiliary tank must be fitted so that its top is below the petrol in the main gravity tank. For pump feed, a special tap union is supplied, so that the tank can be filled by the pump, and then shut off. The petrol supply from the pump to carburettor is shut off when running on the auxiliary tank supply.

Calibration of Carburettor Jets.—It is most important in carburettor construction and testing to know exactly how much petrol is flowing from jets of various sizes and in this connection it is not enough to know the diameter of the jet hole, since jets of the same nominal diameter do not always give the same amount of fuel flow. The only satisfactory method,

therefore, is to actually measure the amount of fuel flowing under standard conditions.

For this purpose the following standard has been laid down for British carburettor jets:—A jet having a smooth regular restriction of not less than 3 diameters long or more than 5, is put under a vertical (static) head of petrol of 50 centimetres measured from the commencement of the orifice, the temperature being 15° C. and the petrol density 0·710. (Fig. 292.)

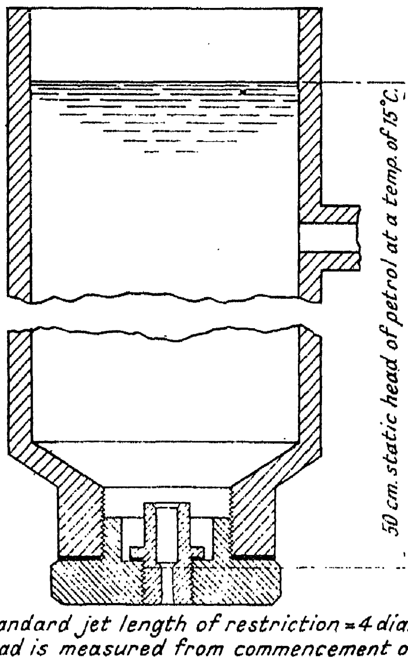


Fig. 292.—Standard Method for Carburettor Jet Tests.

The standard discharge is then measured in cubic centimetres per minute. As the test mentioned occupies at least 2 minutes and probably the jet must be reamered out several times before the desired discharge is obtained a special type of flow meter, i.e., rate-of-flow measuring meter, was devised and is now made by Messrs. Amal, Ltd., Birmingham, to enable rapid readings of jet flow to be taken; in practice the test can be made in 3 or 4 seconds.

Fig. 293 illustrates the Amal jet calibrating device which is used in the vertical position.

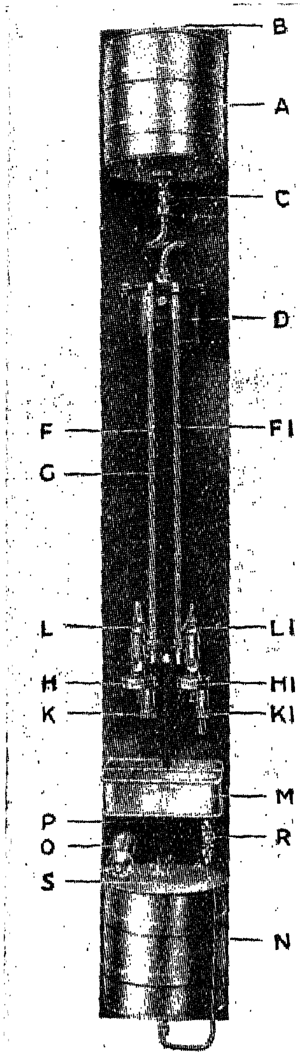


Fig. 293.—Amal Jet Calibration Apparatus.

The petrol passes from tank A, through filter B and tap C, to float chamber D; thence through tube to the body of the instrument, and rises in glass tubes F and F1. The jet to be calibrated is placed in adapter K or K1 and tap H or H1 is turned on by rotating same. The air above the jet is released by means of screws L or L1, and the level of the petrol in F or F1 is read off on scales G. The petrol flowing from the jet is collected through tray M in tank N, and is returned to top tank A, through pipe P, after closing tap R and air release S, by the operation of the pump O.

If a jet be now fixed in either of the Adapters K and K1, and the corresponding Cock H and H1 opened, the petrol in the Gauge Glass above it will fall to a level varying in accordance with the size of the jet, and it is this level which, when read off on the Scales G, gives the calibration of the jet; the level in the Gauge Glass not in use will remain practically at zero. To correct for barometric temperature and density variations, a master jet is supplied with each instrument to which each scale

should be set. This jet should be inserted and the petrol allowed to flow for at least one minute when the mark on the scale corresponding to the master jet size should register level with the petrol in the glass gauge tube.

It should be clearly understood that the master jet is used to set the particular scale which is being used at the time, that is to say: if there is a scale of 20 to 100 on one side, and 100 to 500 on the other, a master jet of say 100 c.c. should not be set on the 100 line on the smaller scale, if the larger scale is being used, and *vice versa*. For absolute accuracy it is desirable to set the scale with a master jet as near as possible to the size of the jet to be calibrated. By this means all variations due to temperature, density, etc., are automatically corrected.

It is of the utmost importance that there should be no air-locks in any part of the instrument. Above the cocks which carry the jet adapters are Air Release Valves L and L1, and these should always be opened momentarily to allow any air which may lie in the jet adapter to escape after the insertion of the jet to be calibrated.

The Amal flow meters are made in three standard sizes, namely, the Mark VIII, IX and XI, and these give scale ranges of 1 to 6 pints per hour up to 21 to 80 gallons per hour.

Checking Mixture Strength by Exhaust Gases.— The relationship between the mixture strength and composition of the exhaust gases, illustrated in Fig. 2, page 16, is made use of in the case of special instruments designed to measure the proportion of carbon-monoxide and dioxide in the exhaust gases of automobile engines. It will be seen by reference to Fig 2 that such instruments will not deal with mixtures weaker than those giving correct proportions for complete combustion of the fuel.

A typical exhaust gas tester is the Marconi Ecko type illustrated in Fig. 294.

This instrument utilises the principle of the variation of thermal conductivity with change in carbon monoxide and dioxide content in the exhaust gas of

internal combustion engines. The thermal conductivity is measured by means of a Wheatstone Bridge consisting of four platinum-wire spirals, two in air and two in the exhaust gas. The bridge unit is mounted in a heavy metal block to equalise the ambient temperature of the arms and the exhaust gas reaches the test arms by diffusion upwards past buffer plates which reduce temperature and condense out water vapour. The reading, it is stated, is not materially affected by variations in the temperature of the gas, and smoke particles are largely excluded because of their low mobility. A special nozzle is inserted into the exhaust pipe of the car under test, and a proportion of the exhaust passes through a flexible rubber pipe to the

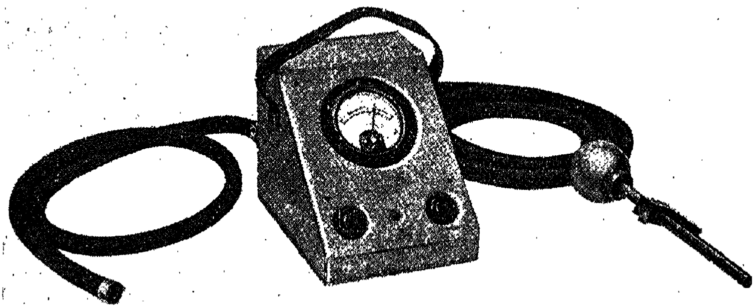


Fig. 294.—The Marconi Ecko Exhaust Gas Analyser.

instrument. The length of this pipe is sufficient to enable the instrument to be placed inside the car for road tests, in which case an aditional flexible rubber pipe carries the exhaust from the instrument through the car window. The calibration of the 3-in. moving-coil indicator is carried out in air/fuel ratio, the range being 15:1 to 10:1, and also in fuel loss, the range in this case being 0·14 per cent. The instrument is battery operated, the batteries being contained in the case, and is supplied complete with the necessary flexible pipes and water trap. The dimensions are $10\frac{1}{2}$ in. by 8 in. by $7\frac{1}{2}$ in., and the weight is 16 lbs. The lengths of the flexible pipes supplied as standard are 7 ft. long, and they are $\frac{5}{8}$ in. diameter.

Another convenient form of exhaust gas analyser used for checking the settings of carburettors in test houses and motor garages is the Engelhard one shown in Fig. 295. It gives continuous readings of mixture strength by measuring the proportion of carbon-dioxide and monoxide in the exhaust gases and is based upon the principle of measuring the thermal conductivity of the gases in question. When the mixture of air and petrol supplied by the carburettor is correct for combustion, i.e., about 15 : 1, the percentage of carbon-monoxide present in the exhaust gases is taken at 14·7 for modern fuels. The latter value drops to 5·7 for an extra-rich mixture of 9 : 1.

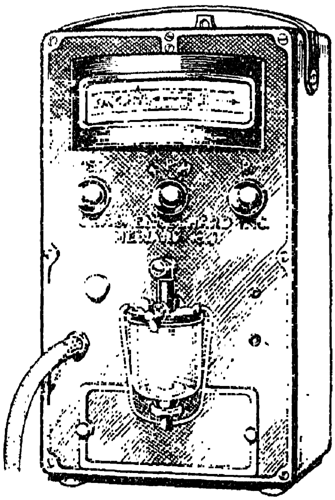


Fig. 295.—The Engelhard Exhaust Gas Analyser.

The scale of the instrument is graduated for mixture strengths of 15 : 1 to 9 : 1, but it should be pointed out that for " lean " mixtures containing more air than the 15 : 1 one, there is no carbon-monoxide in the exhaust; most well-tuned engines will run regularly on mixtures of weakness up to about 18 : 1, with economical results, but with a falling off in power.

In use the sampling tube, shown on the lower left hand side of Fig. 295 is connected to the exhaust pipe—

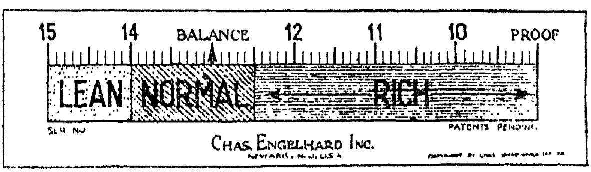


Fig. 296.—Scale of the Engelhard Exhaust Gas Analyser.

which must be free from air leaks and readings are then taken direct from the pointer and its scale. In this manner adjustments to carburettors can be made

and their effects upon the mixture strength at once ascertained.

Another exhaust gas analyzer of an inexpensive nature which operates on the same principle is the Lantz-Phelps. This contains a resistance element which is inserted in the exhaust gases and it gives direct readings of mixture strength.

Average Car Consumptions.—In order to afford some idea as to the average fuel consumptions of modern motor-cars fitted with properly adjusted carburettors, the following table is given:—

TABLE NO. 5.

Average Mileages per Gallon of Modern Cars. (Running on Petrol)

Engine Capacity in Cubic Centimetres.	Petrol Consumption (Miles per Gallon).
600 to 800	45 to 40
800 to 1,000	40 to 38
1,000 to 1,100	38 to 36
1,100 to 1,300	36 to 34
1,300 to 1,500	34 to 32
1,500 to 2,000	32 to 26
2,000 to 2,500	26 to 22
2,500 to 3,000	22 to 18

The petrol consumption will depend to some extent on the weight of the car, and assuming that each car is fitted with the usual appropriate horse-power engine, the following are average values for modern cars:—

TABLE NO. 6.

Average Mileages per Gallon for Different Car Weights. (Running on Petrol.)

Weight of Car (Cwts.)	8	9	10	12	14	16	18	20	22	24
Petrol Consumption (m.p.g.)	50	46	43	37	35	33	31	29	27	25

The appropriate fuel consumption, expressed in miles per gallon can also be ascertained by dividing the number 340 by the Treasury Rating Horse Power.

A well-designed engine should give a minimum petrol consumption of 0·55 pints per B.H.P. per hour when working at full throttle.

If the mixture is *too rich* the power will fall off, and

the engine will show signs of overheating, due to the slower flame velocity; the fuel consumption will rise rapidly.

The *odour from the exhaust* will be more pungent, and a fine *black soot* will be emitted—a sheet of white paper behind the exhaust outlet will show this.

If the colour of the exhaust flame can be seen (at night or in a partly darkened room) it will be a bright yellow for over-rich mixtures.

If the extra-air valve be opened or the fuel needle screwed down (if a variable jet type) the engine will speed up, if the mixture is initially over-rich.

Ton Mileages per Gallon.—Frequently one hears of comparisons being made between the fuel consumptions of certain cars merely on the basis of mileages per gallon, regardless of the actual B.H.P. of the engine and the net loaded weight. The true criterion for a comparison of cars of the same horse power (or engine cylinder capacities) is one which takes into account the weight as well as the mileage run per gallon of fuel. The usual procedure adopted for R.A.C. trials is to express the results in terms of ton miles per gallon, by multiplying the fuel consumption (in m.p.g.) by the total weight of the car (in tons). Thus if a car of 24 cwt. (=1·2 tons) gives a mileage per gallon of 35, the ton miles per gallon will be 1·2 × 35 = 42. This method is an excellent one for road trial results, although a better one would be to divide the result by the cubical capacity of the engine so as to take the power into account. The highest value would then (in either case) represent the best vehicle, i.e., the one which could pull the greatest load with the lowest horse power and fuel consumption.

Most modern light cars* and ordinary cars give a ton m.p.g. ranging from 40 to 60. Motor lorries give much higher values, ranging from 60 to 100. The record hitherto held in this respect is by a Saurer lorry, which, with a total weight of 10 tons 19 cwt. and a 4,529 c.c. engine, gave a mileage per gallon of 11·28, equivalent to 123·34 ton miles per gallon. A

*A special Morris engine gave 52.2 ton miles per gallon.

Solex carburettor with no extra air device, but with exhaust heated air supply, was used. The average speed was about 12 miles an hour over a course of 1,008 miles. With heavy fuel oils, such as Diesel oil, and the compression-ignition cycle of operations it is possible to obtain ton mileages per gallon of 150 to 180.

Carburettor Size and Design.—The carburettor should be sufficiently large, so as to supply the full quantity of mixture; too small a carburettor will throttle the mixture due to the higher gas velocities and smaller passages. The carburettor manufacturers provide lists of carburettor sizes for engines of different capacities. The internal diameter of the carburettor outlet should be the same as that of the inlet manifold, although the latter is sometimes tapered slightly to a smaller throat diameter above the flange.

The cylindrical type throttle is preferable to the butterfly type, as the latter reduces the effective area, causes eddies, and restricts the full throttle charge quantity; usually about 10 to 15 per cent. of the maximum power is lost with the latter type throttle. Carburettors having sharp bends or changes of section for the air or mixture flow, or air entries in different directions, will usually not fill the cylinders sufficiently for the maximum power results. In this respect the straight-through or horizontal type carburettor will give better results than most vertical types. The carburettor should be provided with efficient heating or mixture vaporizing means, a fuel filter, and mixture adjustments for slow and normal running. It should have the absolute minimum of moving and wearing parts, and be quite accessible for cleaning and adjustments.

Judging Carburation by Explosion Flame Colour.—The writer has carried out a number of experiments using quartz windows and sparking-plugs in the combustion chamber, and has found that there is a definite flame colour corresponding to each strength of mixture. Quartz-insulator sparking-plugs are available commercially, but a quartz window can

readily be made out of an old sparking-plug body, as shown in Fig. 297. The following are the mixture colours of combustion:—

State of Mixture.	Characteristic Flame Colour.
Very Weak	Not very intense, faint whitish blue
Medium Weak	More intense, whitish blue
Correct	Maximum intensity, whitish blue
Medium Rich	Light blue with traces of yellow
Very Rich	Bright yellow or orange yellow

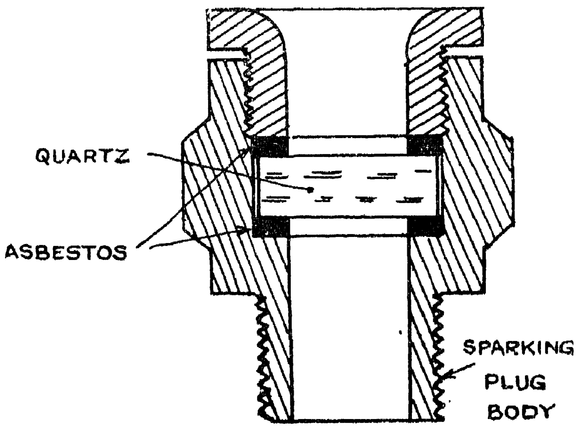


Fig. 297.—A convenient form of Quartz Window for observing Explosion Flames, made from a Sparking Plug Shell.

Scientific Carburation Tests.—It is beyond the scope or intention of the present volume to deal with the more advanced scientific and theoretical sides of carburation, but a few remarks outlining the methods employed may stimulate further interest in these aspects of carburation.*

The usual method of measuring the mixture strength is to run the engine until everything is thoroughly warmed up, and then to maintain the speed, ignition, carburation, cooling and other factors uniform. The quantity of air consumed in a given time is measured, either by means of an air-flowmeter of the "box,"

* Fuller information on scientific and ordinary methods of carburation testing will be found in the author's "Testing of High Speed Internal Combustion Engines." (Chapman and Hall, Ltd.)

electric flow, or pilot types, whilst the quantity of fuel consumed in the same time is measured either with a flowmeter, or a graduated vessel of the type having narrow sections at two places (viz., top and bottom) where the stopwatch times are taken, as it is much more accurate to measure the time of passing a fixed mark when the fuel is flowing rapidly, than when moving through a big section tube slowly. The whole process can be performed automatically; the observer closes a switch when the fuel passes the upper mark, which starts a stopwatch, an engine revolution counter, and an air flow counter. When the fuel passes the lower mark the switch is thrown out, thereby stopping the watch, revolution and airflow counter. From these readings the quantities of air and fuel flowing in a given time are known, and the average engine speed also. By measuring the brake horse power at the same time, preferably with an hydraulic or electric swinging field type of power brake, the corresponding horse power can be obtained.

Another method is to take samples of the exhaust gases, and to analyse these. It is only necessary, however, to measure the proportions of carbon dioxide, oxygen and carbon monoxide, when the corresponding mixture strength can be ascertained at once from curves for the fuel employed, resembling the petrol curve given in Fig. 2.

If one is only concerned in checking carburation for obtaining the correct mixture strength, all that is necessary is to measure the percentage of carbon dioxide; for complete combustion this should be 13·3 per cent. for petrol, for benzole 15·8 per cent. and for alcohol 12·5 per cent. Any smaller percentage corresponds to a richer or weaker mixture. Thus if 10 per cent. of CO_2 is found, the mixture strength is either 19·0 (weak) or 11·5 (rich), the correct mixture being 15·0 for petrol. The exhaust gases may either be analysed in an Orsat apparatus, or the CO_2 proportion actually recorded on a chart, or indicated by a needle and dial by using a CO_2 recorder such as the Cambridge electrical, or Wright types. Alternatively, one of the exhaust gas analyzers previously described can be employed to ascertain the mixture strength. In

this way the carburation of large fleets of vehicles can be checked regularly, and a considerable saving in the fuel bill effected. It is not difficult to ascertain from the percentage of CO_2 found whether this corresponds either to a weak or rich mixture. Thus if 10 per cent. of CO_2 is found, extra air may be admitted; if the engine slows up, this shows that the mixture was on the weak side; if the engine speeds up, the mixture corresponding was on the rich side. Alternatively if on flooding the carburettor the engine works sluggishly, and chokes, with more pungent exhaust, the mixture was on the rich side; if initially weak, flooding will speed the engine up.

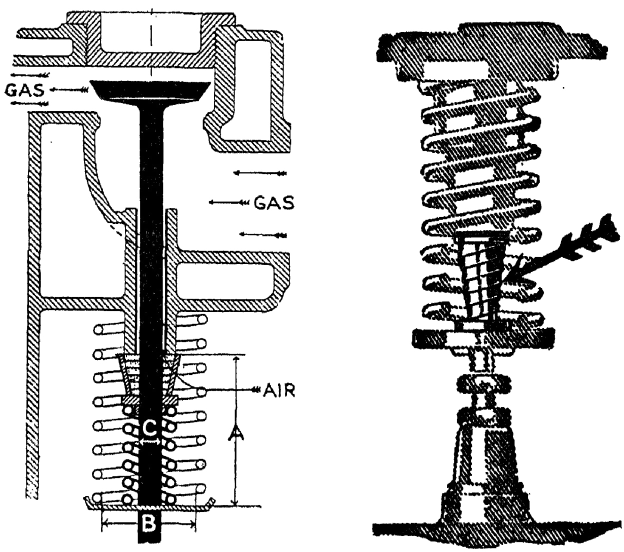


Fig. 298.—*A*—The S.U. Valve Stem Sealer.
B—The Flexigas Valve Stem Sealer.

Mechanical Troubles.—After a period of use, certain minor mechanical troubles may begin to manifest themselves. The *float mechanism* is a frequent offender in this respect. The *collar* on the needle may shift, and thus alter the fuel level. If the *needle valve* or *seating* becomes *worn*, there will be flooding of the carburettor; the remedy is to re-grind the needle valve in its seating, with very fine crocus or knife-powder and oil, finishing with metal polish·

ing paste. A *punctured float* is indicated by fuel leaking from the float chamber or jet. If the float be taken out and shaken it will be found to contain fuel inside; there are, of course, other causes of flooding. A *loose needle valve seating*, due to its having become a little slack or unscrewed, will *cause flooding*. Leakage from the petrol unions, filter or drain plugs indicates bad joints; these should be tightened, and if the leakage does not stop, they should be removed and refaced, or if of the fibre washer type a new one should be put in. Smearing lightly with common *yellow soap* will frequently cure leakage at a joint. After long periods of use the fuel level will often be found to have changed due to wear of the needle valve and its seating, causing the former to sink lower in the latter. In the case of the usual pattern float lever (with seating at base) this effect causes the fuel level to be raised. In the over-head needle type the fuel level will also be raised.

Wear in the cylindrical *throttle* barrel, or butterfly throttle or its bearings, will cause a leakage of air or mixture past the throttle, with the result that the engine will not run slowly. In the case of suction controlled type carburettors, such as the multiple jet one, wear in the suction sleeve or piston will also result in poor running, and in loss of power at full throttle.

Common Faults in Carburettors.—It is now proposed to consider the more common sources of trouble in carburettors; in this respect it should be pointed out that certain designs of carburettor have their own peculiar troubles, which may not be completely covered in these notes. It is assumed that the ignition and other influencing factors are correct.

1. Difficulty in Starting.—*Probable Cause*: (*a*) Air leakage past inlet valve guides, due to wear. This can be cured either by new valves and guides, or more economically by using one or other of the valve stem sealers on the market, such as the S.U. or Flexigas types shown in Fig. 298. The engine cannot be made to run slowly if there is leakage past the valve stems. (*b*) The *slow running* or *pilot jet* may give *too weak* a mixture, or may be stopped up. Th

remedy is to alter the adjustment provided so as to give more fuel, in the former case, and to remove and clean the jet in the latter event. (*c*) The *throttle* may not be open sufficiently to allow enough mixture to flow. Some engines require from $\frac{1}{5}$ to $\frac{1}{3}$ throttle opening for starting. (*d*) The fuel filter may be choked with solid particles.

Any reputable make of carburettor should enable the engine to start, even in cold weather, after flooding the carburettor, or, in more recent types, closing the air choke, and partly opening the throttle. After about six turns of the crankshaft with the ignition "off" the engine should fire when the ignition is switched on, and the starting motor switched on or the starting handle sharply swung around. If the engine will only start after injecting petrol direct into the cylinders, faulty carburation is indicated as above. Otherwise the ignition may be at fault.

It is always advisable to *close the air choke*, or open the adjustable jet, as the case may be, at starting.

Excessive Use of Choke.—A frequent fault exercised by new drivers is to hold the air choke control open, so as to shut off the main air supply, for too long a period when or after starting the engine from the cold. If for any reason the ignition system does not respond at once and the engine is motored around with the choke control in operation the cylinders will become filled with over-rich mixture and this will not ignite. In other instances engines are motored around with the choke closed and the ignition not switched on, due to forgetfulness and a similar state of affairs occurs when the engine is switched on; incidentally, this is bad for the cylinder wall lubrication.

In all such cases the proper procedure to adopt is as follows:—Switch off the ignition. Open the throttle wide. Motor the engine around for a few turns. Close the throttle to its starting stop position and switch on. Leaving the choke control released the engine should then start by motoring with the switch on. The object of this procedure is to dilute the rich mixture sufficiently with air drawn in through the main

carburettor intake to bring it to the proper consistency for starting. It should be pointed out that no petrol will be drawn into the engine from the main (or pilot jets) when the throttle is full open, owing to the low air speed past the main jet.

It is important to release the choke within a minute or so of the engine starting, otherwise an excessively rich mixture will be drawn into the engine and the latter will emit black smoke from the exhaust and may stop. Excessive use of the engine choke which may not cause the engine to stop will usually result in increased cylinder wear.

2. Difficulty in Slow Running.—The causes are the same as those given in (*a*), (*b*) and (*c*). Bad inlet pipe joints may also be the cause. Insufficient heating of the inlet pipe or mixing chamber will often cause sluggish slow running due to bad vaporization of the mixture. Too large a throttle opening is another cause.

3. Engine Refuses to Respond to Throttle Opening.—In such cases the engine may run quite well when idling, but when under load, as soon as the throttle is opened, will not accelerate well or will misfire. Probable cause: (*a*) Too small a main jet—try a larger jet or opening. (*b*) Too large a jet, causing mixture choking—black smoke emitted from exhaust, much carbon of a sooty nature on valve caps and sparking-plugs, excessive fuel consumption. Check by admitting more air, or reducing jet size. (*c*) Too large a choke-tube, giving insufficient jet suction, and resulting weak mixture. (*d*) Too small a choke-tube, giving ultra-rich mixture. (*e*) Jet may be partly clogged with dirt, or fuel filter choked so that in either case not enough fuel flows to keep mixture strength constant. (*f*) *Water in float or jet chambers*. This is drawn up into the jet when the throttle is opened, and the suction increases; it is usually indicated by misfiring as the throttle opens. The whole fuel system should be cleaned. (*g*) Punctured float; this gives too rich a mixture. (*h*) Too high a fuel level in float chamber. (*j*) In the case of suction piston type carburettors, wear between the piston and its cylinder.

4. **Engine will not give Full Power.**—Probable cause: (*a*) Too small a carburettor size, or inefficient design (too many restrictions and tortuous passages for mixture path). (*b*) Throttle accelerator does not allow throttle to be fully opened. (*c*) Too weak a mixture at full throttle; test by using larger main jet or by temporarily flooding jet. (*d*) Too rich a mixture; check by fuel consumption, black smoke at exhaust, reducing main jet size or increasing choke-tube size. (*e*) Air strangler or extra air device does not open sufficiently; the usual symptoms of a rich mixture will here occur. (*f*) Bad throttle design; certain "thick" butterfly throttle designs cause a partial loss of mixture quantity at full opening. (*g*) Engine too cold.

5. **Flooding of Carburettor.**—Evident by fuel dripping from any part, by damp or "wet" unions or fuel pipe, and by the characteristic odour of the fuel. With red Ethyl petrol characteristic red stains are left around leaky joints. Probable cause: (*a*) *Bad Joints*, unions or connections; remedy by tightening, new fibre washers, or by re-trueing joint faces. (*b*) *Punctured float;* shake float to ascertain if any liquid (not particles of solder) are inside. (*c*) *Worn float mechanism*, or *needle valve seating;* check level of fuel in jet; if fuel is constantly overflowing lower level by altering collar on needle valve, as previously explained. (*d*) *Dirt under needle valve;* the float chamber should be cleaned and flushed out with fresh fuel, and fuel filter gauze tested for holes which might allow solid matter to pass. *Momentary dripping* from carburettor may be caused by condensation of fuel in the inlet pipe, after engine has stopped; it indicates either a cold engine or inefficient heating when engine is at its normal working temperature.

6. **Misfiring at High Speeds.**—This may be due to incorrect mixture strength due to the causes outlined in 3. It may also be due to ignition trouble, the spark failing to pass across the sparking plug points under the higher compression due to larger throttle opening; faulty insulation of the plug or carbon deposit on the insulation may cause this. Apart from

the partly starved fuel supply dealt with in 3, the only other likely cause may be one of *pre-ignition*, due to local overheating of the combustion chamber.

7. **Insufficient Heating.**—Bad vaporization, particularly with the heavier fuels, may lead to poor running, the usual symptoms are as follow: (*a*) The engine will not start up readily or run slowly. (*b*) It will misfire for a time after quickly opening the throttle; this is due to fuel deposition and consequent mixture weakening and poor distribution. (*c*) Hesitation when changing gear (down) as when on hills. (*d*) Erratic running, or hunting at the same throttle opening. (*f*) Temporary flooding after engine stops. The heating arrangements should be examined in such cases. The provision of a heated main air supply, and the lagging with asbestos cord of the inlet manifold will usually cure this trouble.

8. **Hunting at Most Speeds.**—Apart from poor vaporization, "hunting," i.e., sudden changes of engine speed with the same throttle opening and ignition setting, and with no change of load, may be caused by the butterfly throttle being loose on its spindle, or to play in the throttle operating levers and pins. A loose main air choke may also be the cause.

Popping or Backfiring in Carburettor.—This is evident as occasional weak explosions in the inlet pipe and carburettor. It is due to too weak a mixture or insufficient heating. The mixture is so weak that the explosion flame travels very slowly through it with the result that inflammation occurs not only during the firing and exhaust strokes, but is still continuing when the inlet valve again opens. It often happens in cold weather at starting; the remedy is to increase the fuel supply or reduce the air supply, and to look for extraneous sources of air leakages.

To Ensure Easy Starting in Cold Weather.—The radiator should be emptied overnight to avoid freezing

of the water in the cooling system. It should be filled with hot water when the car is required for use, and after allowing about five minutes for the heat to be conducted through the cylinder walls, the engine should be "swung" with the starting handle for about six to eight complete turns with the ignition off. After this it should start up on the self-starter, or by swinging sharply by hand. Injecting petrol or ether into the induction pipe or cylinder head, will frequently enable a stubborn engine to start up. Wrapping a hot wet flannel around the induction pipe sometimes helps matters.

In cold weather, one may employ a radiator warming lamp of the Davy-lamp type, such as that illustrated

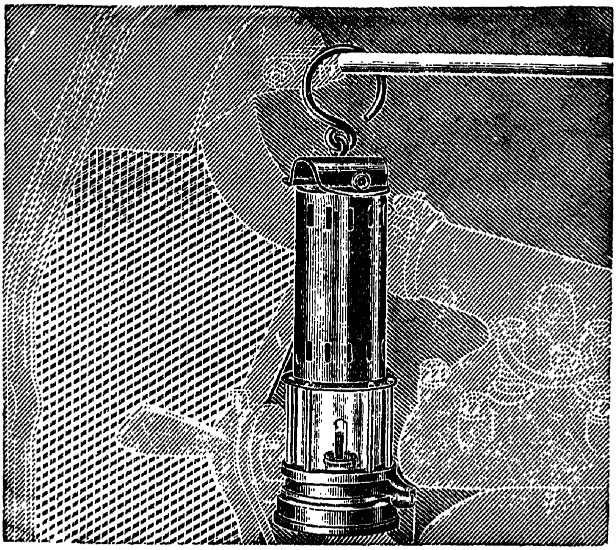


Fig. 299.—The Radiator Lamp shown works on the Davy or Miner's Lamp principle.

in Fig 299. These burn a very small quantity of paraffin oil, and will keep the engine warm for 20 to 24 hours. The catalytic type lamp, which employs

petrol, but is quite safe, is used for this purpose on aircraft engines, in winter.

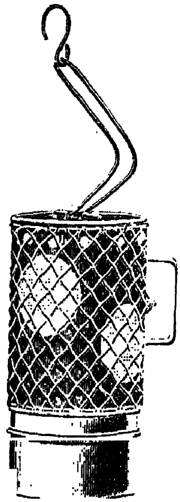


Fig. 300 — The Ever-Warm Radiator Lamp.

If a lamp, such as one of those illustrated, be lighted and placed inside the bonnet of the car overnight, or several hours before the car is to be used, the water will be sufficiently warm to enable starting to be carried out.

The Ever-Warm lamp shown in Fig. 300 is another particularly efficient radiator heater. It operates on the Davy-lamp principle and will burn for 72 hours with one filling of paraffin, a specially large oil container being fitted; it has no glass parts. Some of the larger patterns will burn for 8 days; they are made for placing under the oil sump.

Electric heaters that are plugged into the ordinary lighting circuit lamp holder or wall plug are now employed for keeping the radiator and water jacket from freezing. An excellent heater of this type, having a high reistance heating coil, is that made by the General Electric Co., Ltd., London.

APPENDIX I.

THEORY OF THE CARBURETTOR.

(1) The following is an outline of the simple theory of the carburettor, based upon the assumption that the laws of flow of liquids and gases are, within certain limits, the same.

The flow of a fluid through a tube can be expressed by Bernouilli's energy equation, thus :—

$$\frac{v^2}{2g} + \frac{p}{w} + h = \text{constant.}$$

where v = velocity, p = pressure, h = datum head, g = acceleration due to gravity, and w = the density of the fluid.

If V_1 be the velocity at B (Fig. 1) and V_2 that at A, and p_1 be the pressure at B and p_2 that at A,

$$\text{Then } \frac{V_1^2}{2g} + \frac{p_1}{w} = \frac{V_2^2}{2g} + \frac{p_2}{w}$$

From this equation it will be seen that as the velocity V increases at any section (as at the smallest section of a choke-tube), then the pressure p_1 diminishes. As the pressure at B is assumed to be atmospheric, then at A it will be less than atmospheric. This is the explanation of the petrol flow from the jet placed in the constriction of the choke tube, for the pressure on the petrol in the float chamber is atmospheric.

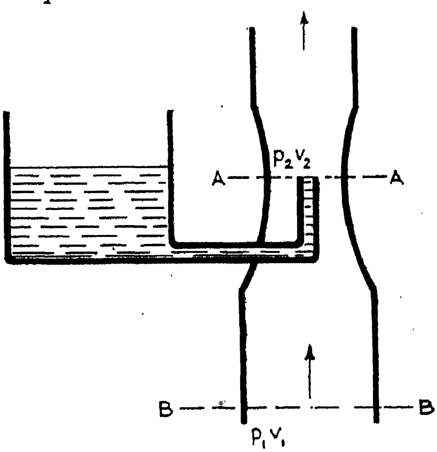


Fig. 1.

(2) The quantity of a fluid flowing through a jet can be shown from an application of the above energy equation to be as follows :—

$$Q = C\,Aw\sqrt{2gh}$$

where Q is the quantity in grammes per sec.

A = cross-sectional area of jet in sq. cm.

C = coefficient of discharge for the particular shape of orifice used.

g acceleration due to gravity (981 cm. per sec., per sec.).

h pressure head at orifice causing the liquid flow.

w = density of the liquid in grammes per c.c.

Whilst this relation gives fairly accurate results under a given set of conditions, it requires a temperature correction for the density of the liquid and an allowance for the frictional head loss due to the liquid flowing through the orifice, in the case of carburettor jets. The density of petrol becomes less as its temperature rises.

Thus $w = w_0[1 - \cdot 0007\ (t - 60)]$

where w is the density at $t°$ Fah. and w_0 that at 32° Fah.

(3) When the equation of fluid flow is applied to air, we have to deal with a compressible substance subject to gaseous laws of pressure, density and temperature, whereas petrol is incompressible and follows a liquid law of flow.

For these reasons we cannot accurately compute the mixture ratios of air and petrol over a range of carburettor air speeds.

When the relation for the flow of air through a venturi is worked out from considerations of the energy equation, adiabatic change and continuity equation, the resulting expression becomes rather complex, so that the solution of carburettor problems by the analytical method is by no means an easy or straightforward one.

To those of our readers wishing to pursue this subject further, we give below some useful references.

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